RELATIONSHIPS AMONG TEMPERATURE, DEPTH, AND ABUNDANCE OF COMMERCIALLY IMPORTANT FISHES CAPTURED BY TRAWL VESSELS IN THE KODIAK AREA OF THE GULF OF ALASKA, USA

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A

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Abstract

Increased understanding of the factors influencing fish distributions and abundance may improve fisheries management and stock assessment models and may provide the fishing industry with a means to reduce bycatch. I investigated the associations of ambient seawater depth and temperature with catches of commercially important species in the Gulf of Alaska. Time-depth recorders were attached to trawl nets to collect depth and temperature data during commercial bottom trawl fishing operations. The data collected from these recorders were combined with species composition data collected by onboard observers to determine associations between these physical variables and catch of fishes. Parameters for depths and temperatures where target species were abundant were identified. Pacific cod were captured in abundance in depths shallower than 130 m while withstanding water temperatures ranging from 2.8 to 8.5°C. Rockfishes were abundant in depth ranging from 52 m to 353 m and temperatures ranging from 4.9 to 8.3°C. Shallow-water flatfishes were captured in abundance in depths shallower than 97 and temperatures from 2.6 to 10.7 °C. Deep-water flatfishes were abundant in depths greater than 115 m and water temperatures ranging from 3.8 to 6.5°C. Arrowtooth flounder, Pacific halibut, and walleye pollock were found in all temperatures and depths analyzed.

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Introduction

Increased understanding of the distribution and abundance of fish species may contribute to effective and efficient fishery management practices. Improved knowledge of the distributions of target species, or conversely, the distributions of non-target species could lead to the development of more selective fishing techniques. The capture of bycatch species, i.e., species not intentionally captured, along with the desired species has long been problematic in the world's fisheries. Bycatch has become a primary issue in national and international fisheries management programs (Alverson and Hughes, 1995). Restrictions on bycatch were in place prior to passage of the Magnuson-Stevens Fishery Conservation and Management Act in 1976 (Witherell, et al., 2000). The North Pacific Fisheries Management Council recognizes bycatch as an important problem affecting the health of fisheries in Alaska (Blackburn and Davis, 1992). Various techniques have been investigated to improve the selectivity of trawl gear to avoid bycatch. These techniques include modifications to cables, footropes, openings in the trawl net (Rose, 1995) and size and shape of the net mesh (Pikitch, et al., 1995). Other management methods include catch limits, monitoring and enforcement programs, spatial and temporal distributions of fisheries, and Marine Protected Areas (Kaiser, et al., 2004; Witherell, et al., 2000). Although many attempts to resolve bycatch problems in fisheries have been made, bycatch remains a critical problem that needs further investigation into potential solutions.

The groundfish fisheries in the Exclusive Economic Zone (EEZ; 0 to 200 miles from shore) off the coast of Alaska are managed by the National Oceanic and Atmospheric Administration Fisheries Division (NOAA Fisheries) and Alaska Department of Fish and Game (ADFG). The ADFG manages groundfish fisheries in waters 0 to 3 miles from shore. NOAA Fisheries manages groundfish fisheries in waters 3 miles from shore to the EEZ boundary. The Federal Fishery Regulations for the groundfish fisheries operating in the Alaska EEZ are published in the Code of Federal Regulations (U.S. Department of Commerce, NOAA, NMFS, Commercial Fishing

Regulations, 50 CFR 600 and 679). The trawl fisheries in the Gulf of Alaska (GOA) are managed with annual harvest quotas termed the Total Allowable Catch (TAC) for the target species. Allowances for bycatch of king crab (*Lithodes* sp., *Paralithodes* sp.), Tanner crab (*Chionoectes* sp.), salmon (*Onchorhynchus* sp.), and Pacific halibut (*Hippoglossus stenolepis)* are also limited annually and, for Pacific halibut, the allowance is divided into quarterly allocations. The retention of catch of king crab, Tanner crab, salmon, and Pacific halibut by groundfish trawl vessels is prohibited by federal regulation; these are termed "prohibited species." Other species may be a target species, a bycatch species, or both, within a calendar year depending on the amount of allowable catch for the species that has been caught. Target species in the Gulf of Alaska (GOA) groundfish fisheries include walleye walleye pollock (*Theragra chalcogramma*), Pacific cod (*Gadus macrocephalus*), various flatfish species (Pleuronectidae), sablefish (*Anoplopoma fimbria*), and rockfishes (*Sebastes* and *Sebastolobus* spp). The preliminary results of the 2003 NOAA Fisheries trawl survey found the most abundant species in the GOA, in descending order, were: arrowtooth flounder (*Atheresthes stomias*), Pacific halibut, walleye pollock, Pacific Ocean Perch (*Sebates alutus*), Pacific cod, and flathead sole (*Hippoglossiodes elassodon*) (National Marine Fisheries Service, 2003).

Federal fishing regulations require vessels greater than 60 feet length overall participating in the North Pacific groundfish fisheries to carry a NOAA Fisheries observer who collects data on the total amount of fish caught by the vessel and samples the catch to determine the relative abundance of each species caught (U.S. Department of Commerce, NOAA, NMFS, Commercial Fishing Regulations, 50 CFR 679.50). Vessels 60 to 125 feet length overall must carry an observer during 30% of fishing days while vessels longer than 125 feet are required to carry an observer 100% of fishing days. Data collected by observers (NOAA Fisheries, Groundfish Observer Program) are used for management of the North Pacific groundfish fisheries.

Observer data are used in part by the North Pacific Fisheries Management Council (NPFMC) to assess, allocate and monitor the fish stocks in the North Pacific Ocean. The NPFMC manages the fisheries in the Bering Sea, Aleutian Islands, and Gulf of Alaska and develops fishery management plans (FMP) for each commercially important species in this jurisdiction. The goals of the FMPs are to prevent overfishing, achieve optimum yield of fish stocks, efficiently utilize the resource, base management decisions on the best scientific data available, and ensure equitable access to all fishers.

Fishers use knowledge based on their experience, or that of other fishers (Ruttan, 2003), regarding the profitability of fishing in a given area (Pelletier and Ferraris, 2000). Trawl fishers rely on collective knowledge of the fishing grounds, needs of the fish market, weather considerations, locations of other fishing vessels, reports from other fishers, ocean currents, in addition to "a lot of hit and miss" strategies to determine where to set their gear (Stinson[1]). Typical groundfish trawl vessels are equipped with instruments displaying the seafloor depth and depth of fishing gear to show the location of their fishing gear in the water column. Many groundfish vessels also use instruments showing water temperature at the sea surface, at gear depth, or both. Information relayed from sonar equipment and depth sounders, combined with historical knowledge of the fishing grounds, provides fishers with a good idea as to what kind of fish are going into the net (Lodge[2]). The co-occurrence of some species is predictable and identification of the seasonal and/or spatial patterns of harvest may be a tool to minimize potential for over- or under-harvest of these species (Murawski and Finn, 1988). Improved understanding of the abundance of fishes associated with measurable variables such as temperature or depth could improve catches of target species and avoidance of bycatch species.

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[1] Stinson, J. 1996 Operator of F/V Alaskan, Kodiak. AK. Personal commun.

[2] Lodge, D. 1995. Alaska Vocational Technical Center, P.O. Box 889, Seward, AK 99664. Personal commun.

The influence of water depth and temperature on distributions of North Pacific fish species is recognized (Norcross, et al., 1995, 1997; Welch, et al., 1995; Wyllie-Echeverria and Wooster, 1998). Some species of commercial interest inhabit adjacent, but separate, depth zones (Adams, 1995). The preferences by a species for a particular temperature range may be related to upper or lower thermal tolerance levels, or seasonal movements such as for spawning (Murawski and Finn, 1988). The exact mechanisms and the extent of influence of depth and temperature on fish abundance and distributions are not currently known.

Time-depth Recorders (TDRs) have proven effective in providing data regarding the environment in which marine mammals and birds live and, presumably, forage for prey (Boveng, et al., 1996; Burns and Castellini, 1998; DeLong, et al., 1992; Merrick and Laughlin, 1997). In this study, I attached TDRs to very large predators, i.e., trawl nets, to collect depth and temperature measurements during fishing operations. This was a unique approach because the water depth and temperature of the trawl net were recorded at the same time the fish were captured. The majority of previous studies collected depth and temperature data some distance from the location of fish capture.

The objective of this study is to use TDRs to assess the relationships among depth, temperature, and catches of commercially important fishes in bottom trawl fisheries. The depth and temperature data presented here could be useful in the development of fisheries management plans. Fishers could use these to more efficiently target on desired species and avoid bycatch species.

Materials and Methods

Data Collection

The Kodiak Island archipelago lies in the northwestern GOA (Figure 1). Primary features of the sea floor are a series of flat shallow banks at water depths of 50 to 100 m dissected by transverse troughs 200 m or more in depth (Bouma and Hampton, 1981; Hampton, et al., 1979; Hampton, 1983). Water temperatures in the region range from 1 to 13°C (Stabeno, et al., 2004). Fishing grounds around Kodiak Island include the southwestern end of the island, bays on both sides of Shelikof Strait, most of the bays around the island, Albatross Banks to the southwest of Kodiak Island, and Portlock Banks to the northeast of island (Thurston[3]).

For this study, species composition, temperature, and depth data were collected in 1995, 1996 and 1997 onboard 33 commercial fishing vessels during normal bottom trawl fishing periods in the Gulf of Alaska. Vessels departed from the port of Kodiak, Alaska, in search of Pacific cod, rockfishes, and flatfish, the primary target species of shoreside delivery bottom trawl vessels in the GOA. Arrowtooth flounder was a bycatch species due to low market value at the time. Commercial fishing vessels from the port of Kodiak typically fished around the island out to depths of approximately 500 meters (Pearson[4]). These vessels ranged from 65-114 feet length overall (average length = 86.5 $\pm$ 11.3 feet), fished for 1-5 days, and held fish onboard in tanks until delivery to a shore-based processing facility. Because vessels of opportunity were used, the trawl net configuration and mesh size were not controlled. The North Pacific Groundfish Observer Program (NPGOP) provided fishery catch and effort data (estimates of the total catch weight and duration of each haul) and fish species composition data. In accordance with NPGOP sampling protocol, species composition data used in the present study were determined from randomly collected sub-samples of the catch (Alaska Fisheries Science Center, 1997).

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[3] Thurston, K. 1997. Operator of F/V Excalibur II, Kodiak, AK. Personal commun.
[4] Pearson, T. 1997. NOAA Fisheries, Kodiak, AK. Personal commun.

When a vessel carried a NOAA Fisheries NPGOP observer, depth and temperature recorders were attached to commercial fishing nets to obtain physical characteristics for each haul where fish were captured. I coordinated with vessel personnel and observers to deploy Time-depth recorders (Wildlife Computers TDR MK6) on the vessels. Permission to attach Time-depth recorders (TDR) to the net was obtained from the operator of each vessel. Vessels were asked to participate only during fishing trips when observers were onboard. TDRs were secured in a protective marine aluminum housing (10.2 x 10.2 x 6.4 cm; 0.45 kg total weight), which did not obstruct the sensors or interfere with performance of the fishing gear. TDRs were secured to the headrope with carabineers and/or line for the duration of a fishing trip. TDRs were programmed to record water depth and temperature every 10 minutes (approximately every 240 m linear distance at an average trawling speed of 3.1 knots during data collection in 1995). Review of data collected in 1995 revealed that the durations of some hauls were less than 60 minutes, resulting in less than 12 depth and temperature readings for the haul. In 1996 and 1997, the frequency for temperature and readings was increased to every 30 seconds (approximately every 48 m linear distance at an average trawling speed of 3.1 knots) to improve on the number of data points collected. TDR data were downloaded using software provided by Wildlife Computers and imported into EXCEL spreadsheets. Once the data were in EXCEL, the author reviewed the data for anomalies or indications of TDR malfunction.

Calibration of TDRs

Wildlife Computers MK6 TDRs are designed to read depth in 2 m intervals (+/- 2 m + 1% of actual water depth) and temperature to +/-0.2°C[5]. Prior to deployment, the operation of the depth and temperature sensors for each TDR was tested using Wildlife Computer's self-testing program (Wildlife Computers, 1994). The depth sensor zero-offset was programmed to record a zero

[5] Wildlife Computers. 2003. Personal commun.

reading when the pressure transducer did not sense pressure due immersion in water during deployment. This test allows the researcher to note any TDRs that do not give the correct depth value when the TDR is out of the water at sea level and reset the depth sensor to read zero at sea level. The temperature sensor was checked to ensure it recorded the ambient temperature of the room (values were visually compared among all TDRs prepared for deployment in a single session and with a room thermometer). The temperature sensor is not known to drift (Wildlife Computers, 1994). None of the TDRs gave indications of malfunction during the study.

Twelve of the 20 TDRs used were calibrated by securing the TDRs onto a rectangular board in a single layer. It was not possible to test eight of the TDRs due to field logistics. Lines were tied to the TDR array such that the array could be lowered into the water and held perpendicular to the surface. A conductivity, temperature, depth recorder (SeaCat SBE19 CTD) was secured to the array to hold the CTD at the same depth as the TDRs. The array was lowered and raised by hand. The array was held just under the surface for 5 minutes and at approximately 40 m for 10 minutes. The depth and temperature readings recorded by each TDR were compared to values recorded by the CTD, the latter of which were used as the standard. TDRs and the CTD were programmed to record data at the same time intervals. All 12 TDRs tested within the manufacturer's readings for depth and temperature for the conditions under which data were collected for this study. Mean values for the TDRs were compared to CTD values and analyzed using analysis of variance (ANOVA) and then a Tukey test (SAS 8.1).

The probability of malfunction by one or more of the non-calibrated TDRs was tested using a binomial distribution test. An assumption that one trial in 12 would fail was chosen as a worst case failure rate for the purposes of testing. Use of the true failure rate (0%; no failures were detected in 12 trials) would not have allowed for the possibility for even one of the non-calibrated TDRs to fail. Based on the assumed probability of failure of $p=0.08$, the probability that any one of the 8 non-calibrated TDRs failed was 0.13 and the probability that any two non-calibrated TDRs failed was 0.02. Given that the calibration tests demonstrated that 100% of the 12 calibrated TDRs performed without failure, the statistical probability demonstrates that it may be assumed that the non-calibrated TDRs also performed without failure (Vining[6]). The statistical probability of acceptable functioning of all TDRs used allowed use of the data recorded by the non-calibrated TDRs.

Data Analysis

Data were collected in January - March in 1996, April - June in 1995 and 1996, July – September in 1995, 1996, and 1997, and October - November 1995 and 1997. Timing of data collection was subject to the timing of open fisheries during these months (Table 1) and availability of equipment and the investigator to deploy the equipment.

Mean Fishing Depth and Temperature

Depth and temperature data were matched to the fishing effort and species composition data from each haul. The mean fishing depth and mean fishing temperature for each haul was determined using the all the values from surface to surface for each haul to ensure use of all depth and temperature values in association with the depth and temperatures where fishes were captured. Thus, all conditions encountered by the trawl net such as currents, seafloor variations, or the net being lifted off the bottom to turn the vessel that potentially affected the capture of fishes in each haul were included. Profiles of the shallowest haul (mean depth = 12 m; Figure 2), the deepest haul (mean depth = 429 m; Figure 3), the shortest haul (duration = 39 minutes; Figure 4), and the longest haul (duration = 485 minutes; Figure 5) show the extremes of the

[6] Vining, I. 2003. Alaska Department of Fish and Game, Kodiak, AK. Personal commun.

depths and time scales for the individual hauls included in this study. Direct comparisons of the depths and durations for hauls in Figures 2 - 5 are not possible because the scale of each figure is set to best display the data in the individual figure. For some hauls, the depth of the haul varied considerably compared to the mean depth of the haul (Figure 2), likely due to the vessel operator following variations on the seafloor. For the majority of hauls, the net was deployed to the fishing depth and remained at a relatively constant depth for the duration of the tow (Figures 3 and 4). During some hauls, the vessel brought the net up from the bottom, but not all the way to the surface (Figure 5). This was a common practice when the vessel needed to change direction. In these situations, the haul was used only if the net was quickly redeployed to the fishing depth. If the net was brought up and not quickly redeployed, the haul was not used due to effect on the duration of the haul. Note that the TDRs recorded depths with accuracy of $\pm$ 2 m, while the trawl nets typically used by vessels in this study had mouth opening heights ranging from 2 to 10 m.

In the GOA, the fisheries for bottom trawl vessels were managed by species or species complexes. The target fisheries were Pacific cod, rockfishes, and walleye pollock (Table 1). A fishery management practice in this region was to group various species into complexes or assemblages of species commonly captured together. The term "shallow water complex" refers to the grouping of walleye pollock, Pacific cod, flathead sole, Atka mackerel, "other" species, and "shallow water flatfish," i.e., Alaska plaice (*Pleuronectes quadrituberculatus*), butter sole (*Pleuronectes isolepis*), English sole (*Pleuronectes vetulus*), northern rock sole (*Lepidopsetta polyxystra*), sand sole (*Psettichthys melanostictus*), southern rock sole (*Pleuronectes bilineatus*), starry flounder (*Platichthys stellatus*), and yellowfin sole (*Limanda aspera)* (DiCosimo and Kimball, 2001). The term "deep water complex" refers to the grouping of sablefish, rockfishes, rex sole (*Glyptocephalus zachirus*), arrowtooth flounder, and "deep water flatfish," i.e., deep-sea sole (*Embassichthys bathybius*), Dover sole (*Microstomus pacificus*), and Greenland turbot (*Reinhardtius hippoglossoides*) (DiCosimo and Kimball, 2001). I analyzed catches of Pacific cod, rockfishes, the flatfish species within the "shallow water complex" (hereafter refered to as SW flatfishes), the flatfish species within the “deep water complex” (hereafter refered to as DW flatfishes), arrowtooth flounder, walleye pollock and Pacific halibut. For the purposes of this study, hauls capturing greater than or equal to 50% by weight of Pacific cod, rockfishes, SW flatfishes or DW flatfishes were designated as hauls where these species or species complexes were the targeted species. The percentage of the catch as the basis for a target species definition is used for stock assessments (Williams and Chen, 2004). Pacific cod, rockfishes, SW flatfishes or DW flatfishes were considered abundant in the hauls where they were the target. Arrowtooth flounder were a bycatch species and were termed abundant in hauls that captured greater than or equal to 35% by weight of arrowtooth flounder compared to the total catch. Although the fishery for walleye pollock was open during the study periods, walleye pollock were not considered as a target species in this study because vessels typically use mid-water trawl gear in this fishery. Walleye pollock were considered abundant in hauls where capture was greater than or equal to 20% by weight of the total catch. For arrowtooth flounder and walleye pollock, I used the percent bycatch by weight criteria used by NOAA Fisheries (U.S. Department of Commerce, NOAA, NMFS, Commercial Fishing Regulations, 50 CFR 679.20(e)). Pacific halibut were a bycatch species and designated as abundant in hauls where the catch was greater than or equal to 4% by weight of the total catch. This bycatch rate for Pacific halibut is in accordance with the NOAA Fisheries regulations (U.S. Department of Commerce, NOAA, NMFS, Commercial Fishing Regulations, 50 CFR 679). Catch per unit effort (CPUE; kilograms of fish caught per hour) was used to standardize catch rates among vessels of all species captured and of species described above within each haul.

The mean temperature, mean depth and CPUE data for each haul were analyzed both using all haul data for a species together and these data separated by year and by fishing period (January - March; April - June; July - September; October - November). Analysis of Variance (ANOVA) was used to test the null hypothesis that neither mean water temperature nor mean fishing depth was significantly related to the CPUE of fishes. Associations among temperatures, depths, and the CPUE of the seven most abundant species captured (Pacific cod, rockfishes, arrowtooth flounder, SW flatfishes, DW flatfishes, walleye pollock, and Pacific halibut; Table 2) were assessed using SAS version 8.1 (two-way ANOVA, proc GLM, alpha = 0.05).

The CPUE of Pacific cod, rockfish, SW flatfishes and DW flatfishes along with arrowtooth flounder, walleye pollock and Pacific halibut in each haul was plotted with the mean CPUE of the haul, mean depth of the haul, and mean temperature of the haul to show the relationships among the species. For the bycatch species, arrowtooth flounder, walleye pollock, and Pacific halibut, plots of the CPUE of the individual species versus the CPUE of the haul in which the species was captured were made to visually inspect for patterns of association with the mean temperature or depth of haul. Student's t-test (alpha = 0.05) was used to determine the significance of differences in mean CPUE with depth or temperature for hauls where the mean CPUE was greater than 2,000 kg/hr (arrowtooth flounder) or 500 kg/hr (walleye pollock and Pacific halibut). The CPUE criteria were selected on the basis of visual inspection of graphs and based on groupings of high values which appeared to break apart from clusters of lower values.

Results

Fifty-one species of commercial importance weighing a total of 6058 t were caught in 874 hauls (Table 2) in 1995, 1996 and 1997. CPUE was determined for 806 hauls. Pacific cod, rockfishes, arrowtooth flounder, SW flatfishes, DW flatfishes, walleye pollock and Pacific halibut, were the seven most abundant species or species complexes captured composing 94% of the total catch biomass (Table 2). Pacific cod was caught in the greatest abundance composing 30% of the total weight of species captured and was present in 78% of hauls. All of the rockfishes composed 19% of total catch biomass despite the fact the fisheries for all rockfish species were open for only 25 days or less in each year of this study (Table 1). Rockfishes were caught in 48% of hauls. A non-target species, arrowtooth flounder, was the third most abundant species and composed 17% of the total catch biomass but was present in 82% of hauls. SW flatfishes composed 13% of total catch biomass and were caught in 78% of hauls. Nine percent of total catch biomass was composed of DW flatfishes which were caught in 9% of hauls. Walleye pollock, not a target species of the participating vessels, composed 5% of the total catch biomass and was present in 41% of hauls. Pacific halibut composed only 4% of the total catch biomass, but was captured in 77% of hauls.

Plots of the CPUE of the fishes analyzed (Pacific cod, rockfishes, SW flatfishes, DW flatfishes, arrowtooth flounder, walleye pollock, and Pacific halibut) from the individual hauls that targeted Pacific cod (Figure 6a-b), rockfishes (Figure 7a-b), SW flatfishes (Figure 8a-b), or DW flatfishes, (Figure 9a-b) rdisplayed the relative abundance of these species within individual hauls. However, patterns of distinct associations of species among these species within hauls were not found for any of the species or species complexes.

Distribution of Hauls by Fishing Period

The species composition of hauls varied with each fishing quarter. In January - March, the primary target species for vessels in this study was on Pacific cod and SW flatfishes. Ninety-six percent of hauls made in January - March captured Pacific cod (Table 3), 86% percent captured SW flatfishes (Table 4) and 82% captured Pacific halibut (Table 5; Figure 10). The majority of hauls were made in depths less than 150 m and the mean temperatures of all hauls in this period varied from 2.5 to 6.0°C (Figure 11a). In April - June, fishing effort focused on the SW and DW flatfishes (Figure 12). Ninety-three percent of hauls in this period captured Pacific halibut, 91% captured arrowtooth flounder (Table 6) and 63% captured SW flatfishes. All hauls except two were made deeper than 320 m or shallower than 140 m with the mean temperatures of hauls narrowing to 3.0 to 5.5°C (Figure 11b). The walleye pollock, shallow water complex, deep water complex and rockfish fisheries were open in July – September (Table 1) resulting in the highly mixed composition of fishes captured (Figure 13). Rockfishes were targeted in July – September, but not in the remaining months of the year (Table 7) whereas Pacific cod (Table 3), SW flatfishes (Table 4) and DW flatfishes (Table 8) were captured as a target species during all months of the year. Rockfishes were present in 68% of hauls while arrowtooth flounder were present in 94% of hauls made in July- September. SW flatfishes and DW flatfishes were captured in 73% and 74%of hauls respectively. The mean depths of hauls varied from 20 to 440 m and mean temperatures of hauls varied from 4.0 to 11.0°C (Figure 11c). Over half the hauls used in this study (410 of 806 total hauls) were made in July – September, which could be a factor in the variation of depths and temperatures of hauls compared to the other fishing periods in addition to the mix of target fisheries conducted in this period (Table 1). Pacific cod were prevalent in October – December (Figure 14) occurring in 95% of hauls, but 100% of hauls made in this period captured SW flatfishes. Ninety-six percent of hauls also captured Pacific halibut. With the exception of one haul, all hauls in these months were made in depths less than 150 m (Figure 11d). The mean haul temperatures ranged from 5.0 to 9.5°C (Figure 11d).

Pacific Cod

Pacific cod tolerated a wide range in temperatures while maintaining a narrow depth range. The mean depth of all hauls capturing Pacific cod was 81 $\pm$ 24 m; the mean temperature of these hauls was 3.9 $\pm$ 0.5°C. The mean depth of hauls targeting Pacific cod was 88 $\pm$ 18m; the mean temperature of these hauls was 4.0 $\pm$ 0.4°C.The mean depths for all hauls where Pacific cod was the target species varied from 31 $\pm$ 10 m (n = 7) in April - June 1996 to 88 $\pm$ 18 m (n = 123) in January – March 1996 (Table 3). All hauls where Pacific cod was the target species occurred in depths less than 140 m (Figure 6a). The mean temperatures for all hauls where Pacific cod was the target species varied from 4.0 $\pm$ 0.5°C (n = 8) in April - June 1996 to 7.9 $\pm$ 0.3°C (n = 13) in October - November 1995 (Table 3; Figure 6b). Pacific cod were captured in abundance in depths shallower than 130 m in water temperatures ranging from 2.8 to 8.5°C (Figure 15a-b).

The ambient seawater temperature, fishing depth and the interaction of depth and temperature are influenced the catch of Pacific cod by trawl vessels for all hauls capturing this species ($n = 636$, $F = 31.57$, $p < 0.0001$) and for those hauls that targeted Pacific cod ($n = 209$, $F = 3.01$, $p = 0.0310$;Table 9). The association of the depth and temperature of individual hauls on the CPUE of Pacific cod varied with time of year (Figure 15a-b).

Depth, temperature and the interaction of depth and temperature affected the CPUE of Pacific cod in all hauls where this fish was captured in January - March (mean = 2826 kg/hr, $n = 165$, $F = 4.67$, $p = 0.0037$; Table 9). As with the aggregate data, there was little effect on all hauls where Pacific cod was the target species, depth, temperature and the temperature depth interaction were not significantly related to the CPUE of Pacific cod (mean = 3669 kg/hr, $n = 123$, $F = 0.73$, $p = 0.5339$; Table 9). The largest hauls of Pacific cod occurred in January – March (Figure 15a-b).

Hauls capturing Pacific cod in April - June were similar in depth and temperature to the previous three months (Table 3). Catches of Pacific cod were only 20% of what they had been (mean = 540 kg/hr; Table 9; Figure 15a-b) and neither temperature nor depth were significantly related to the CPUE for all hauls capturing this species in April - June ($n = 54$, $F = 0.48$, $p = 0.6987$; Table 9). However, for those hauls where Pacific cod was the target species the CPUE was significantly related to depth, temperature, and the interaction of depth and temperature (mean = 1005 kg/hr, $n = 8$, $F = 10.25$, $p = 0.0239$; Table 9).

In July – September, only 4% of hauls targeted Pacific cod (Table 3). For all hauls where Pacific cod was captured the CPUE was low (mean = 329kg/hr; Table 9; Figure 15a-b), but catch of Pacific cod was influenced by depth, temperature, and the interaction of depth and temperature ($n = 286$, $F = 9.59$, $p < 0.0001$; Table 9). Conversely, the CPUE for hauls where Pacific cod was identified as the target species was higher (mean = 1301 kg/hr) but depth, temperature, and the interaction of depth and temperature were not significant (n = 17, F = 0.12, p = 0.9480; Table 9).

Forty-four percent of hauls made in October - November, targeted Pacific cod (Table 3). The Pacific cod target fishery was open in October - November (Table 1) and, as expected, the CPUE of Pacific cod (mean = 1574 kg/hr; Table 9; Figure 15a-b) was higher than the previous six months due to the concentration of fishing effort on this fish. The CPUE of Pacific cod was related to depth, temperature and the interaction of depth and temperature both for all hauls capturing this species (n = 131, F = 7.00 p = 0.0002; Table 9) and for hauls where it was the target species (n = 61, F = 6.36, p = 0.0009; Table 9). In each fishing period, hauls that targeted on Pacific cod were made in a narrow depth range (53 m) but relatively wide temperature range (3.7°C).

Rockfishes

All catches of rockfishes by trawl vessels were significantly related to the fishing depth and ambient water temperature (n = 379, F= 7.56, p <0.0001) and to targeted catches (n = 98, F = 7.19, p = 0.0002; Table 10). The majority (73%) of hauls capturing rockfishes occurred in July - September (Table 7; Figure 16a-b). Catches of rockfishes in the remaining months were comparatively very low and almost non-existent because rockfish were not targeted and were taken as incidental catch. All hauls where rockfishes were the target species occurred in depths less than 360 m, and most were less than 240 m (Figure 7). The mean depths for all hauls where rockfishes were the target species varied from 53 $\pm$ 14 m (n = 11) in July - September 1995 to 145 $\pm$ 55 m (n = 36) in July - September 1997 (Table 7). The mean temperatures for all hauls where rockfishes were the target species ranged from 6.0 $\pm$ 0.5°C (n = 51) in July - September 1996 to 6.9 $\pm$ 0.6°C (n = 11) in July - September 1995 (Table 7). One haul with very high CPUE of rockfishes (114, 670 kg/hr) was omitted so as not to skew the analysis. Rockfishes were abundant in depth ranging from 52 m to 353 m and temperatures ranging from 4.9 to 8.3°C.

SW Flatfishes

The CPUE of SW flatfishes for all hauls where these fishes were captured was affected by fishing depth, temperature, and the interaction of depth and temperature ($n = 636$, $F = 26.08$, $p < 0.0001$; Table 11). The same was true for all hauls that targeted on SW flatfishes ($n = 87$, $F = 4.79$, $p = 0.0040$; Table 11). Shallow-water flatfishes were captured in abundance in depths shallower than 97 and temperatures from 2.6 to 10.7 °C (Figure 17a-b).

During January - March, 85% of hauls made captured SW flatfishes (Table 4). The mean depth of these hauls was 83 $\pm$ 42m and the mean temperature was 3.9 $\pm$ 0.5°C (Table 4). Depth, temperature, and the temperature/depth interaction helped determine the CPUE of SW flatfishes (mean = 427 kg/hr, $n = 145$, $F = 6.75$, $p = 0.0003$) for all hauls capturing SW flatfishes, but not for hauls where SW flatfishes were targeted (mean CPUE = 853 kg/hr, $n = 26$, $F = 2.03$, $p = 0.1394$; Table 11).

Ninety-one percent of hauls made in April - June, captured SW flatfishes (Table 4). The mean depth of hauls was 63 $\pm$ 40m and the mean temperature was 4.3 $\pm$ 0.5°C. In this fishing period,the CPUE of SW flatfishes (mean = 835 kg/hr) was not significantly related to depth, temperature, and the temperature/depth interaction for all hauls ($n = 55$, $F = 2.57$, $p = 0.0640$) or for hauls that targeted SW flatfishes ($n = 8$, $F = 2.66$, $p = 0.1840$; Table 11).

In July - September, 73% of hauls captured SW flatfishes (Table 4). The mean depth of hauls was 130 $\pm$ 66m and the mean temperature was 6.4 $\pm$ 1.2°C (Table 4). Depth, temperature, and the temperature/depth interaction affected the CPUE of SW flatfishes (mean = 347 kg/hr, $n = 298$, F = 30.03, p < 0.0001) for all hauls capturing these fishes but did not affect hauls targeting SW flatfishes (mean = 2429kg/hr, n = 33, F = 1.90, p = 0.1512; Table 11).

All hauls made in October-November captured SW flatfishes (Table 4). The mean depth of these hauls was 76 $\pm$ 30 m and the mean temperature was highest of all months 7.7 $\pm$ 0.7°C. The CPUE of these fishes was significantly related to depth, temperature, and the temperature/depth interaction for all hauls (mean = 490 kg/hr, n = 138, F = 5.02, p = 0.0025) and for only the hauls targeting SW flatfishes (mean = 2231 kg/hr, n = 20, F = 9.81, p = 0.0007; Table 11). In each fishing period, hauls that targeted on SW flatfisheswere made in a narrow depth range (51 m) but relatively wide temperature range (4.0°C).

DW Flatfishes

The CPUE of DW flatfishes was significantly related to the fishing depth, temperature, and the interaction of depth and temperature for all hauls where these fishes were captured (mean CPUE = 577 kg/hr, n = 436, F = 22.95, p <0.0001). However, the same was not true for only those hauls that targeted DW flatfishes (mean = 2803 kg/hr, n = 83, F = 0.89, p = 0.4482; Table 12). Deep-water flatfishes were abundant in depths greater than 115 m and water temperatures ranging from 3.8 to 6.5°C (Figure 18a-b).

During January - March, 32% of hauls made captured DW flatfishes (Table 8). The mean depth of these hauls was 118 $\pm$ 76 m and the mean temperature was 4.0 $\pm$ 0.6°C (Table 8). Depth, temperature, and the interaction of depth and temperature were important with respect to to the CPUE of DW flatfishes for all hauls capturing these fish (mean CPUE = 203 kg/hr, n = 54, F = 7.88, p = 0.0002; Table 12). An ANOVA for hauls targeting DW flatfish made in January – March was not completed due to an insufficient number of hauls.

In April - June, 51% of hauls captured DW flatfishes (Table 8). The mean depth of hauls was much deeper (307 ± 147m) than in January – March, but the mean temperature of hauls was similar (4.2 ± 0.4°C). Depth, temperature, and the interaction of depth and temperature affected the CPUE of DW flatfishes for all hauls where they were captured (mean CPUE = 1188 kg/hr, n = 44, F = 2.86, p = 0.0486) but did not affect hauls where they were the target (mean CPUE = 2682 kg/hr, n = 16, F = 3.23, p = 0.0607; Table 12).

Seventy-four percent of the hauls made in July - September captured DW flatfishes (Table 8). The mean depth of all hauls capturing DW flatfishes was shallower (162 ± 65m) the April – June. The mean temperature increased to 6.0 ± 0.9°C (Table 8). Depth, temperature, and the interaction of depth and temperature influenced the CPUE of DW flatfishes for all hauls (mean CPUE = 610 kg/hr, n = 302, F = 4.87, p = 0.0025); however they had no influence on those hauls where these fishes were the target (mean CPUE = 2782 kg/hr, n = 61, F = 1.23, p = 0.3077; Table 12).

Only 26% of the hauls made in October-November captured DW flatfishes (Table 8). The mean depth of these hauls (104 ± 41 m) was comparable to the depths in January – March and the mean temperature was highest of all months 7.4± 0.9°C. Depth, temperature, and the interaction of depth and temperature were significant to the CPUE of these fishes (mean = 490 kg/hr, n = 36, F = 17.78, p <0.0001; Table 12). Only two hauls targeting DW flatfish were made in October – November, an insufficient number to perform an ANOVA. DW flatfishes were captured in abundance across the deeper range of hauls (154 m or greater) and moderate range of temperatures (1.8°C) (Figure 18a-b).

Arrowtooth Flounder

Fishing depth, temperature, and the interaction of depth and temperature affected the CPUE of arrowtooth flounder for all hauls where this species was captured (mean = 737 kg/hr, n = 676, F = 9.21, p < 0.0001; Table 13). No relationship was found between the mean temperature (t = 0.45, p = 0.65) and depth (t = 0.82, p = 0.41) of hauls with the highest CPUE (>2,000 kg/hr) of arrowtooth flounder and the mean depth and temperature of hauls where CPUE of arrowtooth flounder was less than 2,000 kg/hr. The discrepancy between the ANOVA and Student's t-test could indicate depth and temperature influence CPUE of arrowtooth flounder but that the design of the current study did not reveal this relationship. Arrowtooth flounder were captured all temperatures and depths analyzed (Figure 19a-b).

During January - March, 66% of hauls made captured arrowtooth flounderas bycatch (Table 6). The mean depth of these hauls was 98 ± 58m and the mean temperature was 3.9°C ± 0.6°C (Table 6). The factors of depth, temperature and the temperature/depth interaction were significant in relation to the CPUE of arrowtooth flounder (mean = 215 kg/hr, n = 113, F = 21.60, p < 0.0001) (Table 13).

In April - June, 91% of hauls captured arrowtooth flounder (Table 6). The mean depth of hauls was deeper than the previous three months and the variation in depth was greater (190 ± 164m), but the mean temperature was similar (4.2 ± 0.4°C). However, unlike the previous timeframe, the CPUE of arrowtooth flounder was not related to depth, temperature and the temperature/depth interaction (mean = 439 kg/hr) in April - June (n = 79, F = 2.21, p = 0.0941; Table 13).

Of the 410 hauls made in July - September, 94% captured arrowtooth flounder (Table 6). The mean depth of all hauls was 144 ± 69 m and the mean temperature was 6.2 ±1.1°C (Table 6). The mean depths and temperatures of individual hauls varied widely (20 to 430 m; 4.0 to 11.0°C;

Figure 19a-b). The mean CPUE of arrowtooth flounder (1013 kg/hr) was higher in July - September than any other season. The CPUE of arrowtooth flounder was related to depth, temperature, and the interaction of depth and temperature ($n = 384$; $F = 7.05$, $p = 0.0001$; Table 13).

Seventy-two percent of hauls made in October-November captured arrowtooth flounder (Table 6). The mean depths of these hauls were shallower than in previous months, 81 $\pm$ 32 m, and the mean temperature was highest of all months, 7.6 $\pm$ 0.8°C. The CPUE of arrowtooth flounder was related to depth, temperature, and the interaction of depth and temperature (mean = 594 kg/hr, $n = 100$, $F = 11.33$, $p < 0.0001$; Table 13).

Walleye Pollock

ANOVA indcated the CPUE of walleye pollock was not related to depth, temperature, and the interaction of depth and temperature during any time frame examined in this study (mean = 224 kg/hr, $n = 333$, $F = 1.39$, $p = 0.2469$; Table 14). However, the mean fishing depth (96m) of hauls where CPUE of walleye pollock was greater than 500 kg/hr ($n = 28$) was significantly different ($t = 1.98$, $p = 0.05$) from mean fishing depth (128 m) of hauls where CPUE of walleye pollock was less than 500 kg/hr ($n = 305$). The mean temperature (6.6°C) of hauls where CPUE of walleye pollock was greater than 500 kg/hr was significantly different ($t = 2.39$, $p = 0.02$) than the mean temperature (5.8°C) of the remaining hauls. As with arrowtooth flounder, this discrepancy between the ANOVA and Student's t-test could indicate the design of the current study did not reveal the extent of the influence of depth and temperature on CPUE of walleye pollock. Walleye pollock, a non-target species, was captured in each fishing period but never in more than 55% of hauls within a fishing period and were found in all temperatures and depths analyzed (Figure 20a-b; Table 15).

Pacific Halibut

Pacific halibut were captured in all temperatures and depths analyzed (Figure 21a-b) The fishing depth, temperature, and the interaction of depth and temperature affected the CPUE of Pacific halibut for all hauls where this species was captured (mean = 179 kg/hr, n = 627, F = 2.79, p = 0.0397; Table 16). The mean fishing depth (155 m) of hauls where CPUE of Pacific halibut was greater than 500 kg/hr (n = 47) is significantly different (t = 2.56, p = 0.01) from mean fishing depth (107 m) of hauls where CPUE of Pacific halibut was less than 500 kg/hr (n = 579). The mean temperature (6.2°C) of hauls where CPUE of Pacific halibut was greater than 500 kg/hr was not significantly different (t = 1.30, p = 0.20) than the mean temperature (5.9°C) of the remaining hauls indicating an influence due to temperature may exist but was not conclusive in this analysis.

Eighty-two percent of hauls made in January - March captured Pacific halibut. The mean depth of hauls capturing Pacific halibut in January – March was 83 ± 42m; the mean temperature of these hauls was 3.8 ±0.5 °C (Table 5). Depth, temperature, and the interaction of depth and temperature affected the CPUE of Pacific halibut (mean = 41 kg/hr, n = 140, F =5.83, p = 0.0009; Table 16).

The occurrence of Pacific halibut in hauls increased to 93% in April – June. The mean depth of hauls capturing Pacific halibut in April - June was deeper (176 ± 161m) that the previous fishing period and the mean temperature of hauls was slightly higher (4.2 ± 0.4°C; Table 5). The hauls capturing Pacific halibut in April - June included very shallow (20m) to very deep (430m) hauls and mean haul temperatures ranged from 3.0 to 5.5°C (Figure 21a-b). Depth, temperature, and the interaction of depth and temperature helped influence the catch of Pacific halibut (mean = 279 kg/hr, n = 81, F = 5.98, p = 0.0010; Table 16).

An association of the CPUE of Pacific halibut with the depth and temperature of hauls in the July - November was not indicated (Table 16). Sixty-seven percent of hauls in July – September and 96% of hauls in October-November caught Pacific halibut (Table 5). The CPUE of Pacific halibut in July – September (mean CPUE = 204 kg/hr, $n = 274$, $F = 0.25$, $p = 0.8630$) and in October – November (mean CPUE = 211 kg/hr, $n = 132$, $F = 1.75$, $p = 0.1604$; Table 16) was not affected by depth, temperature, or the interaction of depth and temperature.

Discussion

My results identify depth and temperature ranges where Pacific cod, rockfishes, arrowtooth flounder, SW flatfishes, DW flatfishes, walleye pollock and Pacific halibut were captured by trawl vessels during commercial fisheries. The results also indicate the influence of temperature or depth on the catch of these fishes. This information adds to the knowledge of the environmental variables that may affect the catches of these species and potentially could be used to reduce bycatch in the groundfish fishing industry. Fishers in the bottom trawl fisheries could use the depth and temperature findings presented here to reduce bycatch species such as Pacific halibut or arrowtooth flounder while more efficiently targeting on desired species such as Pacific cod, rockfishes, and flatfishes.

Increasing the body of knowledge regarding the factors influencing fish distribution may improve fisheries management and stock assessment models. In the Atlantic cod fishery, catches are forecast based on biomass, cumulative landings, and water temperature (Chen and Shelton, 1996). The distributions of fish stocks could potentially be predicted by monitoring the depths and temperatures where fishes are found in abundance (Perry and Smith, 1994). The identification of relationships between fish distribution and temperature and/or depth may provide the fishing industry with a means to reduce bycatch of unwanted or prohibited species. Fishers with the appropriate equipment could use knowledge of depth and temperature relationships to fish in areas of higher potential yield of the target species. Several studies describe the distributions of fishes in relation to environmental variables such as depth, temperature and salinity, but in most of these studies, the environmental variable data used were collected in close proximity to the gear capturing fishes but not actually attached to the gear itself. Few studies on commercially important fishes use commercial fishing vessels operating under normal conditions as a platform. The present study is unique in collecting environmental data using microprocessors attached to the trawl nets capturing the fishes studied and collecting the data using commercial fishing vessels during typical fishing operations. Determining the *in situ* environmental parameters associated with the capture of fish species when they are caught may lead to advances in understanding of distributions and habitat of these species. Data such as those presented here may be used to implement temporal or spatial fishery closures, or open fishing periods, based on bottom depth or water temperature profiles.

The identification of habitat associations of marine fishes provides insight into distributions of fishes and changes in these distributions. Relationships among the distributions of fishes and environmental factors such as temperature, depth, salinity, and substrate have been demonstrated (Chen, 1983; Murawski and Finn, 1988; Murawski 1993; Norcross, et al., 1995; Perry and Smith, 1994; Scott, 1995 Welch, et al 1995). Fishes show a tendency to congregate within regions of species-specific preferred temperatures (Reynolds and Casterlin, 1979). Demonstrated preferences by a fish species for a particular environmental condition such as a narrow temperature range may be related to the distribution of prey species, upper or lower thermal tolerance levels, or seasonal movements such as for spawning (Murawski and Finn, 1988). Several fish species may be categorized as “temperature keepers” or as “depth keepers” (Perry and Smith, 1994). Depth keepers are those species that will tolerate a wide range of temperatures to maintain a relatively narrow depth range. Temperature keepers are those species that will tolerate a wide range of depths to maintain a relatively narrow temperature range (Perry and Smith, 1994). Data from the present study indicate that Pacific cod and SW flatfishesmay be depth keepers. However, further investigation is needed to determine if these apparent effects were real or were a result of the nature of the commercial trawl data used in this analysis. The fishing depth and temperature data used in this study may be confounded by the fisheries management practices, fishing seasons, and market concerns affecting the fishers' decision making with respect to when and where to operate.

Pacific cod, rockfishes, arrowtooth flounder, shallow water flatfish, deep water flatfish, walleye pollock, and Pacific halibut seven of the most economically and ecologically important fishes in the GOA trawl fisheries. Pacific cod, shallow water flatfishes, deep water flatfishes, walleye pollock, and Pacific halibut are highly lucrative target species in the Alaskan fisheries. Arrowtooth flounder is the most abundant groundfish species in the GOA (Turnock et al., 2002). During the years of this study, 1995, 1996, and 1997, the economic value of these fishes ranged from \$66.17/t (USD) for arrowtooth flounder to \$3,725.75/t (USD) for Pacific halibut (Table 17; DiCosimo and Kimball, 2001). Pacific halibut are economically important because of the high price paid to the longline fishers who allowed by regulation to catch halibut via individual fishing quotas. Additionally, federal regulations for trawl fisheries in the GOA require that when the quarterly allowance of halibut bycatch has been met, the trawl fisheries are closed for the remainder of the fishing period regardless of the amount of any groundfish target species that may be remaining in the quota for each species (Table 1). Thus, catches of halibut in the trawl fisheries limit the total allowable catch (TAC) of groundfish target species harvested (Witherell and Pautzke, 1997) which has a negative economic impact on the groundfish industry. During the years of the present study, halibut bycatch limits caused closures of bottom trawl fisheries on twenty occasions.

The catches of fish in this study within each fishing period (e.g., Figures 10, 12, 13, 14) illustrate typical trends in the bottom trawl fisheries in each fishing period in accordance to the target species allowed by regulation within each period. In January – March, vessels targeted primarily on Pacific cod and then shifted effort to the shallow and deep water complexes, usually when the Pacific cod fishery closed. In April - June, the target fisheries typically were the shallow and deep water flatfish complex. Catches of Pacific halibut were often high in comparison to catch of target species. The high catches of halibut at depth in these months (Figure 21a) may be catch of halibut as the trawl net transitioned to fishing depth and not actually catch of halibut at the mean fishing depth of the haul. The bottom trawl fisheries in July – September targeted several species or species complexes (Figure 13). It was typical in these months for a given target fishery to be open for only a few weeks or days at a time. The bottom trawl fishery was once again dominated by Pacific cod in October – November. As in the first months of the year, in the fall months fishing effort shifts to shallow and deep water complexes when the Pacific cod fishery closes.

Pacific cod may be a “depth keeper,” i.e., tolerating a range of temperatures to maintain a more narrow depth range. Hauls where Pacific cod was the target species occurred in less than 130 m mean depth, but occurred in a wide range of temperatures (Figure 6; Table 3). The catches of Pacific cod in this study were found in similar depths (National Marine Fisheries Service, 2004; Perry, et al., 1994) and temperatures (Perry, et al., 1994) to those previously reported. Pacific cod in the waters off of British Columbia were captured in temperatures of 6 to 11°C and depths from 40 to 120 m in May and June (Perry, et al., 1994). In the GOA, Pacific cod spawn in January through April along the continental slope and shelf (40 to 290 m) and are most prevalent on the shelf edge and upper slope (100 –200 m) throughout the year (National Marine Fisheries Service,2004). In the present study, most Pacific cod were caught shallower than 130 m; with some Pacific cod captured in hauls as deep as 350 m. In the Bering Sea, Pacific cod are found near the shelf break (200 m) in fall and winter (Shimada and Kimura, 1994). In spring and summer months, Pacific cod are found on the outer Bering Sea shelf and in shallower depths (30-50 m) in central Bristol Bay (Shimada and Kimura, 1994). The highest total catch biomass of Pacific cod in this study was on the shallow end (50-70 m) of the overall depth distribution reported by other authors (National Marine Fisheries Service, 2004; Perry, et al., 1994; Shimada and Kimura, 1994). This was probably due to fishing effort concentrating on the Portlock and Albatross banks, a series of flat shallow banks on the northeast side of Kodiak Island (Figure 1). These banks are included in the typical fishing grounds for vessels fishing in the region (Thurston[7]).

SW flatfishes were captured in similar temperatures and depths as Pacific cod (Figure 8, Table 4), and may be "depth keepers." This was expected because Pacific cod are included in the shallow water complex for fisheries management purposes. Fishers are known to maximize their allowed catch of Pacific cod when participating in the shallow water complex fishery (Smoker[8]) and, potentially, catches of Pacific cod in individual hauls could be as high in the periods when Pacific cod is the only species targeted. Other studies examing the distributions of adult flatfish by depth and temperature in this region have not been conducted. DW flatfishes were captured in abundance in relatively shallow depths (115 m) to the deepest depths analyzed (429 m). Catches of DW flatfishes are often associated with catches of arrowtooth flounder as both are included in the deep water complex for fisheries management purposes. The discrepancies between the significance of the ANOVA for all hauls capturing Pacific cod, SW flatfishes and DW flatfishes and for hauls where Pacific cod, SW flatfishes and DW flatfishes were targeted may indicate that while particular depths or temperatures are associated with catch of these fishes, the relationships are not strong enough to use depth or temperature as a predictor of catch in abundance.

Rockfishes in the present study were captured in similar temperatures to those reported for Pacific Ocean Perch (*Sebastes alutus*) in British Columbia (4.8 to 6.7°C; Scott 1995), but in slightly warmer than the habitat reported for Pacific Ocean Perch in the Bering Sea (Brodeur, 2001). Aggregations of Pacific Ocean Perch are found in the Pribilof submarine canyon in the

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[7] Thurston, K. 1997. Operator of F/V Excalibur II, Kodiak, AK. Personal commun.
[8] Smoker, A. 2004. NOAA Fisheries, Juneau, AK. Personal commun.

Bering Sea in 4-5°C water and depths of 185 – 240 m with highest abundance at 198 m (Brodeur, 2001). A direct comparison between the present study and the Bering Sea study is not appropriate because the Pribilof canyon study investigated the habitat of Pacific Ocean Perch via nighttime ROV observations and the rockfishes in the present study were captured by trawl vessels during daylight hours when the rockfishes were feeding. However, the troughs in the Portlock and Albatross banks near Kodiak Island may provide habitat for Pacific Ocean Perch similar to habitat identified in the Pribilof canyon (Brodeur, 2001).

In the present study, arrowtooth flounder were caught throughout the temperature range and depth range of all hauls made (Figure 19). Because arrowtooth flounder were captured in 82% of hauls made, the apparent significance of the temperature/depth relationship for capture of arrowtooth flounder cannot be separated from the real relationship of water temperature with water depth. The temperatures and depths of hauls capturing arrowtooth flounder presented here illustrate the temperatures and depths of all hauls made.

Arrowtooth flounder are widely distributed with fish less than age-4 primarily found on the continental shelf and older fish found in 100-200 m on the continental shelf and slope (National Marine Fisheries Service, 2004). Co-occurrence of arrowtooth flounder with other groundfish species is expected because arrowtooth flounder are a aggressive predators of other groundfish species (Zimmerman 1997) with walleye pollock composing as much as 66% of the prey by weight (Yang and Nelson, 2000). In turn, walleye pollock and Pacific cod prey on smaller arrowtooth flounder (National Marine Fisheries Service, 2004). In the present study, catches of arrowtooth flounder in July - September were more than twice as high as the other fishing periods, possibly reflecting aggregations of this species for spawning which occurs in September through March (Zimmerman, 1997). Fishers avoided arrowtooth flounder due to their low market value during the years of this study. The high abundance of arrowtooth flounder in the GOA and the predator-prey relationships among arrowtooth flounder, walleye pollock, and Pacific cod may explain the frequent occurrence of arrowtooth flounder in hauls in the present study.

Walleye pollock were caught throughout the ranges of hauls made, but catches of walleye pollock were not influenced by water temperature or gear depth (Figure 20). My results do not reveal information on specific temperature or depth ranges where walleye pollock would be captured in abundance by bottom trawl vessels. This may be because walleye pollock are not a typical target species for the gear type in this study and participating vessels did not concentrate fishing effort on walleye pollock. Walleye pollock are typically targeted by vessels using mid-water trawl gear, although it is legal to target walleye pollock with bottom trawl gear (U.S. Department of Commerce, NOAA, NMFS, Commercial Fishing Regulations, 50 CFR 679.20). The distribution of a fishing fleet is expected to follow the distribution for the target species, not bycatch species (Salthaug and Aanes, 2003). Although walleye pollock were a bycatch species, they were the sixth most abundant fish captured and was caught in 41% of hauls in this study. The Total Allowable Catch (TAC) limits for groundfish do not allocate among gear types. Thus, fish caught as bycatch are deducted from the TAC of that fish and may impact the duration of the fishery when the fish is a target and may be sold at market.

Pacific halibut are actively avoided by fishers, yet they were captured in 77% percent of hauls in this study (Table 5). Because Pacific halibut were captured in such a high percentage of hauls, albeit in a low weight per haul percentage, it is impossible to conclusively separate the effects of depth and temperature on Pacific halibut from the correlation of water temperature with the depth of hauls. As with arrowtooth flounder, the apparent temperature/depth significance for capture of Pacific halibut is associated with the real relationship of water temperature with water depth.

The ranges of temperatures where Pacific halibut were captured in this study (3.0 to 11.0 °C) are similar those previously reported. In Resurrection Bay, approximately 300 km northeast of

Kodiak Island, halibut were found in slightly warmer water temperatures (4.3 to 12.2°C) but primarily remained in temperatures of 5.8 to 6.2°C and in depths from near the surface to deeper than 400 m (Seitz, et al., 2004). The most favorable water temperatures for Pacific halibut are 3 to 8 °C (Thompson and Van Cleve, 1936).

The data presented here may represent the best currently available data on the temperature distributions of adult Pacific halibut captured by commercial fishing gear in the GOA (Loher[9]). This information could be used by fishers to avoid Pacific halibut and allow full utilization of the allowable catch of groundfish species. Pacific halibut are the bycatch species of primary concern in the GOA trawl fisheries. During the years of the present study, halibut bycatch limits caused closures of various target fisheries on twenty occasions. The economic value of the Pacific halibut to the country and the historical importance of the domestic longline halibut fishery led to this species being the first to receive protection as a bycatch species in the North Pacific groundfish fishery. In 1985, the NPFMC set a limit on the total amount of Pacific halibut that could be caught as bycatch in the groundfish fisheries (Blackburn and Davis, 1995).

In this study, CPUE is used as an indicator of the presence of species at a given depth and/or temperature. However, it is important to not give CPUE values undue significance. CPUE is a measure of abundance of fishes in areas of high density, but should not be construed as a random or systematic sample of fish distribution (Hilborn and Walters, 1992). The true abundance of fishes may not be revealed by CPUE values because factors such as market price, hold size, operational costs (fuel, wages), and fishing regulations may influence fishers decisions regarding when and where to set their gear more strongly than fish abundance (Ruttan, 2003). Other factors influencing the CPUE include the catchability of fish, efficiency of the search for fish, patchiness of the distribution of fish, local depletion of fish, spatial distribution of fishing vessels, desirability of the fish captured (e.g., size of fish), fishers' experience, and information sharing

[9] Loher, T. 2004. International Pacific Halibut Commission. Seattle, WA. Personal commun.

among fishers (Hilborn and Walters, 1992; Ruttan, 2003; Salthaug and Aanes, 2003). Catchability of fish and the spatial concentration (patchiness and spatial distance) of the fishing fleet are linearly related (Salthaug and Aanes, 2003). The spatial distribution of fishing effort may be important to the relationship between CPUE and fish abundance (Gaertner and Dreyfus-Leon, 2004), however, the spatial concentration of fishing fleet was not analyzed in the present study. The duration of a tow varies more with fish abundance and the target species than with gear size (Ragnarsson and Steingrimsson, 2003). These limitations of using CPUE are intrinsic to data collected in a commercial fishery, but should not diminish the usefulness of using CPUE in studies on commercial fisheries. For some studies, a simple criterion for CPUE, such as that used in this study (kg/hr), can provide useful information (Jimenez, et al., 2004; Ruttan, 2003).

The definition of target species used in this study was simplistic but similar to that used in other studies (Jimenez, et al. 2004; Pelletier and Ferraris, 2000). Although target species for this study was defined by species composition on a haul by haul basis, it is important to note that the catch may not be truly reflective of the species the fisher intended to catch (Pelletier and Ferraris, 2000). The intent of this study was to determine the depth and temperature where fishes were captured irrespective of the species the individual fisher intended to catch. The present analysis explored these factors associated with positive catch data for each haul. An analysis of the conditions where these fishes were not captured would be the subject of a future study. The present analysis was focused on presence of species, rather than absence of species, because fishers set gear in locations where they believe there are specific kinds of fish present (Gaertner and Dreyfus-Leon, 2004; Pelletier and Ferraris, 2000; Salthaug and Aanes, 2003) and where the seabed is suitable for the type used (Ragnarsson and Steingrimsson, 2003).

The trawl fleet in this study is described as a single unit that approximates the GOA commercial groundfish trawl fishery but is not applicable to other fisheries. Each fishery has its own unique variety of vessel sizes, gear types, fishing grounds, and markets (Jimenez, et al., 2004; Pelletier

and Ferraris, 2000). The vessels in the current study are of similar size, use similar gear, fish on similar grounds, and deliver fish to similar markets in a single port.
In the oceans of the northern hemisphere, the temperature of the upper water layer increases from March through August due to increased solar energy reaching the sea surface (Pickard, 1975). In the Kodiak Island region of the Gulf of Alaska, minimum seasonal water temperatures occur in March and maximum seasonal water temperatures occur in August. Winds in this region are cyclonic during the fall through spring months, with a rise in storm activity in October to March. The stronger storms contribute to the deepening the ocean mixed layer during the cool months. The winds are more variable during May through September. Weak to moderate cyclonic systems are interspersed with periods of anti-cyclonic winds resulting in periodic upwelling events. Wind mixing activity peaks in the winter months and but is reduced during the summer months. The surface mixed layer is usually greater than 35 m in winter, but may be less than 25 m in the summer in the Kodiak Island region (Stabeno, et al., 2004).

The data presented here reflect these water temperature trends. The mean temperatures of hauls progressed from cool temperatures in January through June (Figures 11a and 11b), warmer temperatures in July through September (Figure 11c) and started to cool again in October and November (Figure 11d). Near surface water temperatures varied throughout the year due to absorption of solar energy and the effects of wind mixing. Water temperatures in hauls deeper than 200 m remained relatively constant (3.8 to 6.2^{o}C) throughout the seasons.

The intent of this study was to identify temperatures and depths where fishes were captured in abundance and investigate the influence of temperature or depth on the capture of fishes. Although water temperature and water depth are correlated (Pickard, 1975), for the purposes of this study they were considered as independent variables. If the ANOVA performed indicated the water temperature/depth correlation only, and not the influence of water temperature and depth on the CPUE of fishes, I would expect the ANOVA for walleye pollock to be significant as was the case for the other bycatch fishes, arrowtooth flounder and Pacific halibut. However unlike arrowtooth flounder and Pacific halibut, while walleye pollock were captured throughout the range of temperatures and depths where hauls were made, the ANOVA was not significant. Thus the ANOVA indeed served as an indication of the influence of temperature, depth, or the temperature/depth interaction on the CPUE of the fish analyzed, and did not only assess the correlation of water temperature with water depth.

The data collected for this study did not allow for distinguishing whether the fishes caught were captured at the described temperatures and depths because the fishes prefer these conditions or merely reflected the opportunistic nature of the sampling at these temperatures and depths. The hauls were likely conducted at particular temperatures or depths because the targeted fish were present in those environmental conditions, but it is unknown whether these data represent optimal depth and temperature conditions for the target species in this study. Arrowtooth flounder, Pacific halibut, and walleye pollock were not target fishery species in this study and the data regarding where these species were captured may indeed be more reflective of actual distributions of these species in relationship to depth and temperature than the expertise of the vessel master in targeting a desired species.

Future Research

The results presented here provide some insight to the CPUE of fishes in relationship to depth and temperature of the fishing gear that captured the fishes but there are many more questions to be answered. It could not be determined if fishes studied were captured at the temperatures and depths reported because the fishes preferred those conditions or because this is where the fishers set their gear. The temperatures and depths of target species during closed fishing periods were not determined. Last, but not least, the relationship between the intended target species and the actual catch was not determined.

A systematic survey of the fishing grounds and adjacent areas to assess the catches of fishes in relationship to depth and temperature would provide additional information on the catch of fishes in relationship to depth and temperature to that presented in this study. A more complete picture of the habitat of fishes in the GOA would result. Information on the distributions of target species when they are not being targeted would be very useful. Future studies should collect data on the gear configurations and intended target species for each haul from the fishers. A systemic design to data collection of depth, temperature, and species composition, rather the opportunistic design of the present study, would allow for better comparisons between fishing periods and years of data collections. The data collected in the present study could be further analyzed for depth and temperature relationships for all species captured, depth and temperature of hauls where a species of interest was not captured, and further analysis of catches among years and fishing periods. This would provide increased understanding of the relationships of catches of fishes with the variables depth and temperature.

Inferences regarding abundance of fishes in this study are confounded by the collection of data using only vessels of opportunity during open commercial fisheries. Data on abundance of fishes in relationship to depth and temperature during non-fishing periods were not collected. The timing of fisheries seasons in the GOA is a complex blend of ecological and economical considerations. Weather is also a frequent factor in the timing, location, and duration of fishing trips and may have affected data collections. However, use of TDRs attached to the trawl nets on vessels of opportunity allowed for collection of data during typical fishing operations and provides a unique view to the conditions affecting capture of fishes in the commercial trawl fisheries.

Conclusions

My results identify depth and temperature ranges where Pacific cod, rockfishes, arrowtooth flounder, SW flatfishes, DW flatfishes, walleye pollock, and Pacific halibut are captured by trawl vessels and the associations of temperature or depth on the catch of these fishes. Pacific cod are captured in highest abundance in depths shallower than 130 m while withstanding water temperatures ranging from 2.8 to 8.5°C. SW flatfishes are abundant in water shallower than 97 m and temperatures ranging 2.6 to 10.7°C. Rockfishes are most abundant in hauls ranging 52 to 353 m and temperatures ranging from 4.9 to 8.3°C. DW flatfishes were captured in abundance in depths greater than 115 m and water temperatures ranging from 3.8 to 6.5°C. Arrowtooth flounder, Pacific halibut, and walleye pollock are found in all temperatures and depths studied. Time-depth recorders are effective tools that may be used to investigate the catches by trawl vessels of commercially important fish species in relationship to ambient water depth and temperature.

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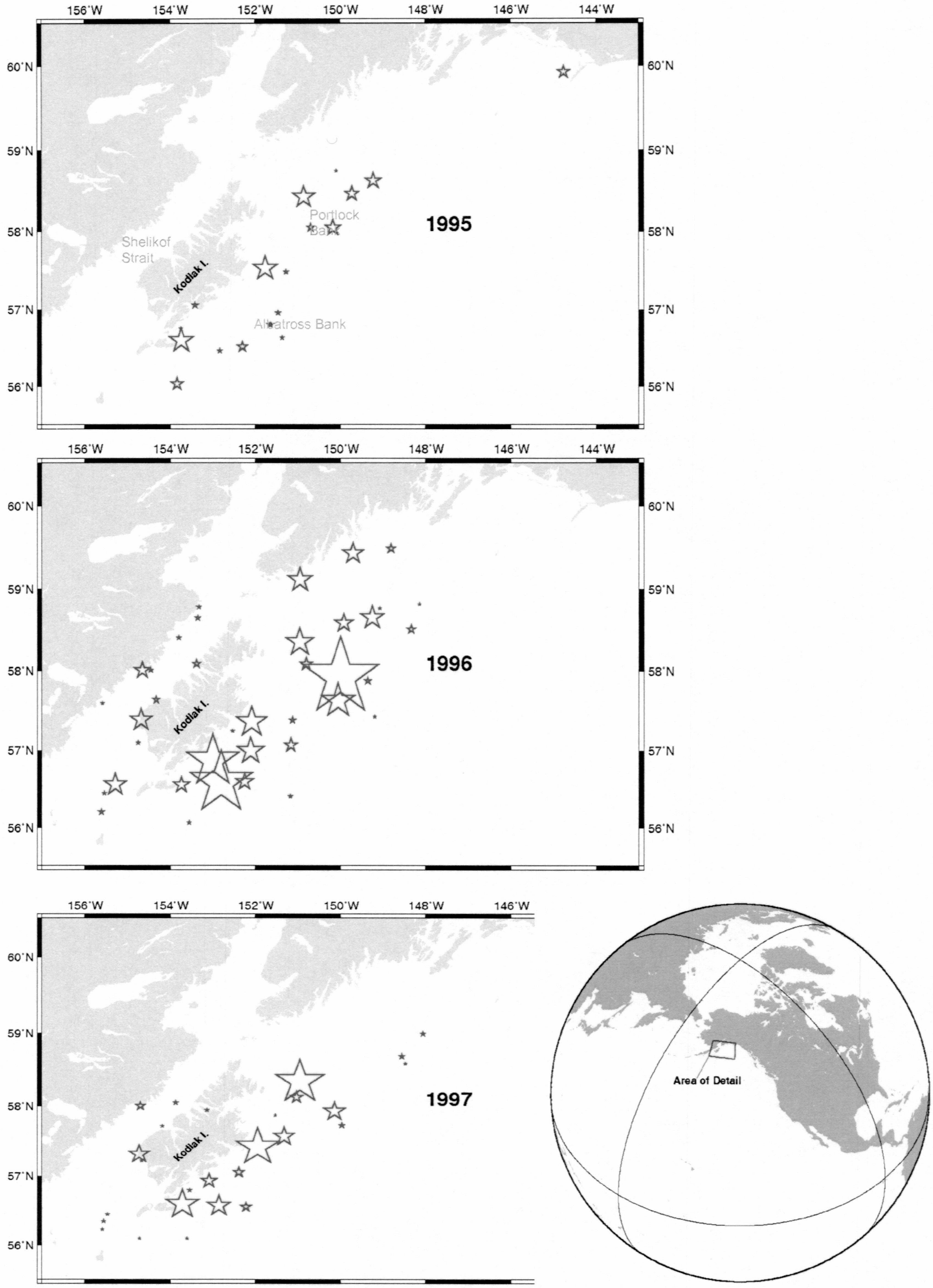


Figure 1. Locations from study sites over three years, 1995-1997. Sizes of stars are proportional to the number of hauls within each 1 degree longitude by 0.5 degree latitude grid.

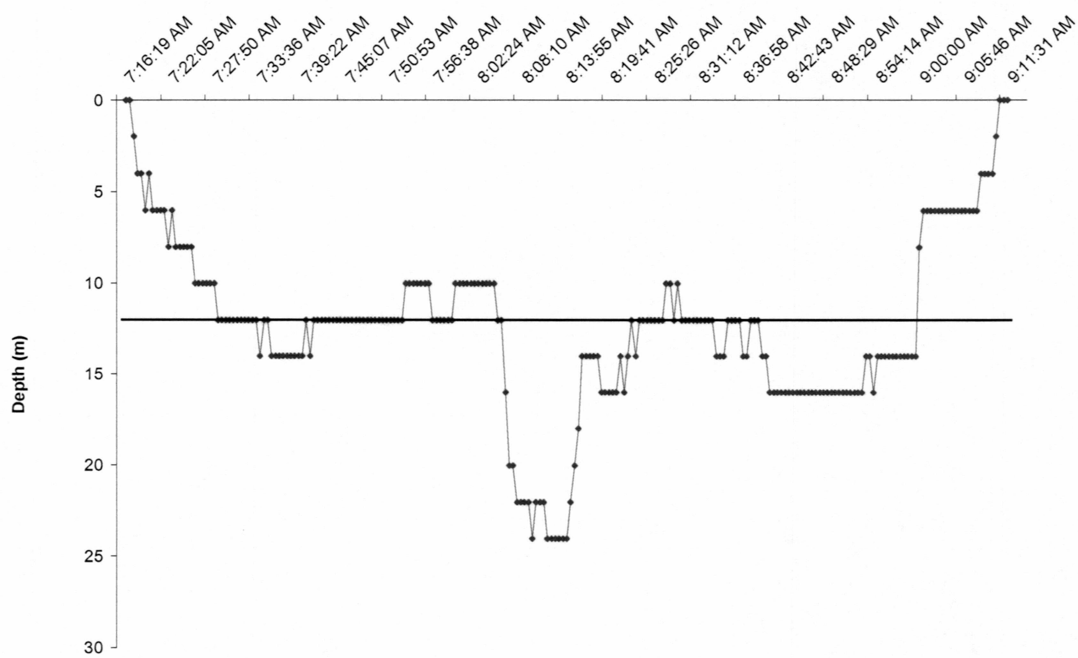


Figure 2. Profile of haul with shallowest mean fishing depth (12 m) indicated by horizontal line . March 5,1996.

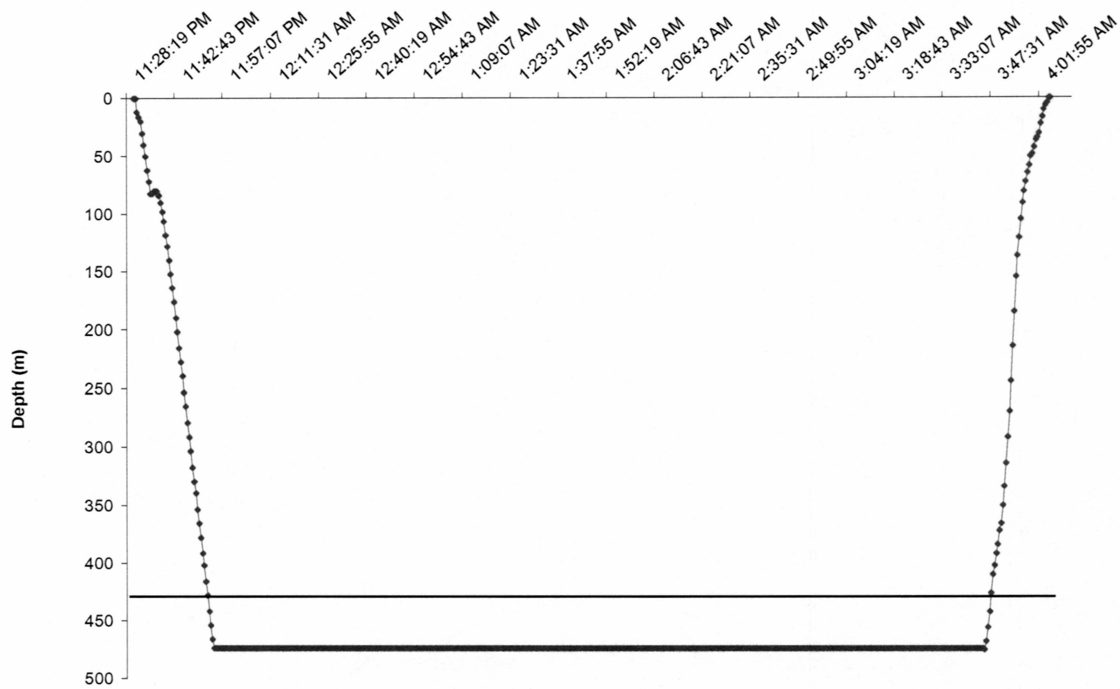


Figure 3. Profile of haul with deepest mean fishing depth (429 m) indicated by horizontal line. March 5-6,1996.

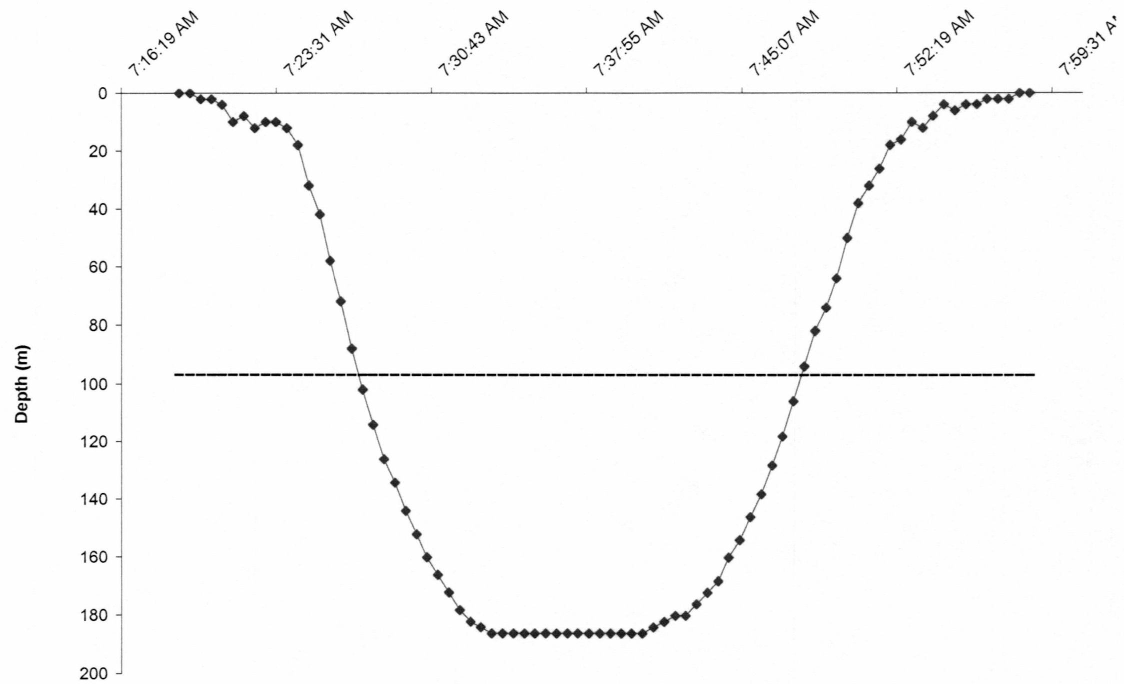


Figure 4. Profile of haul with shortest duration (39 minutes). The horizontal line indicates the mean fishing depth of haul (97 m). July 7,1997.

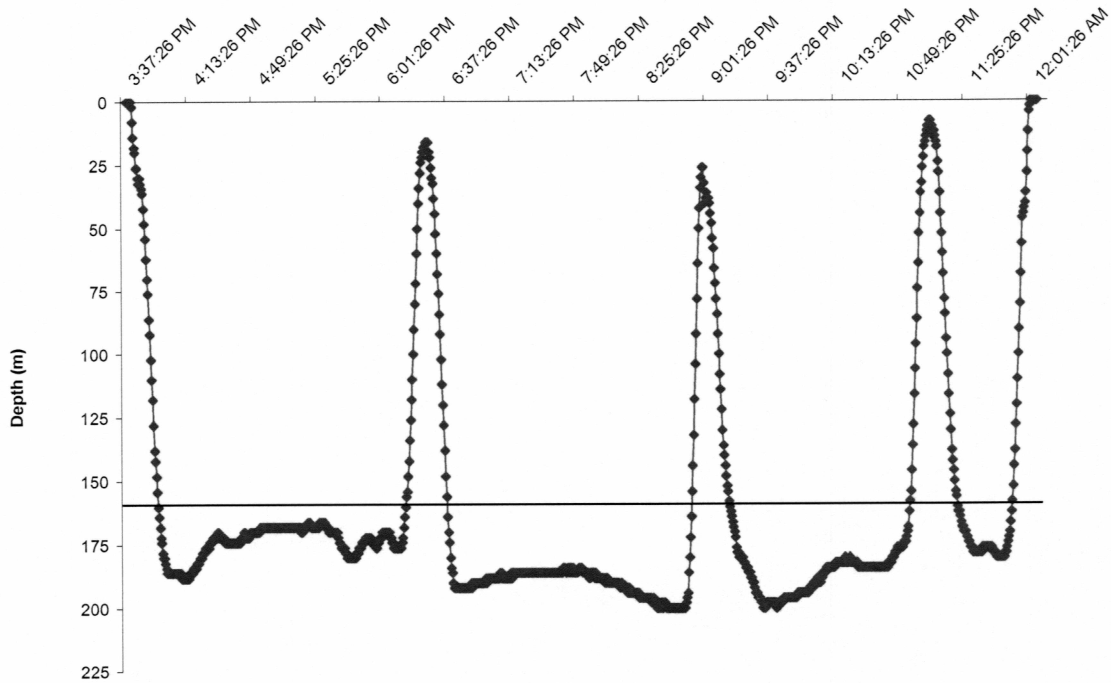


Figure 5. Profile of haul with longest duration (485 minutes). The horizontal line indicates the mean fishing depth (159 m). April 6-7,1997.

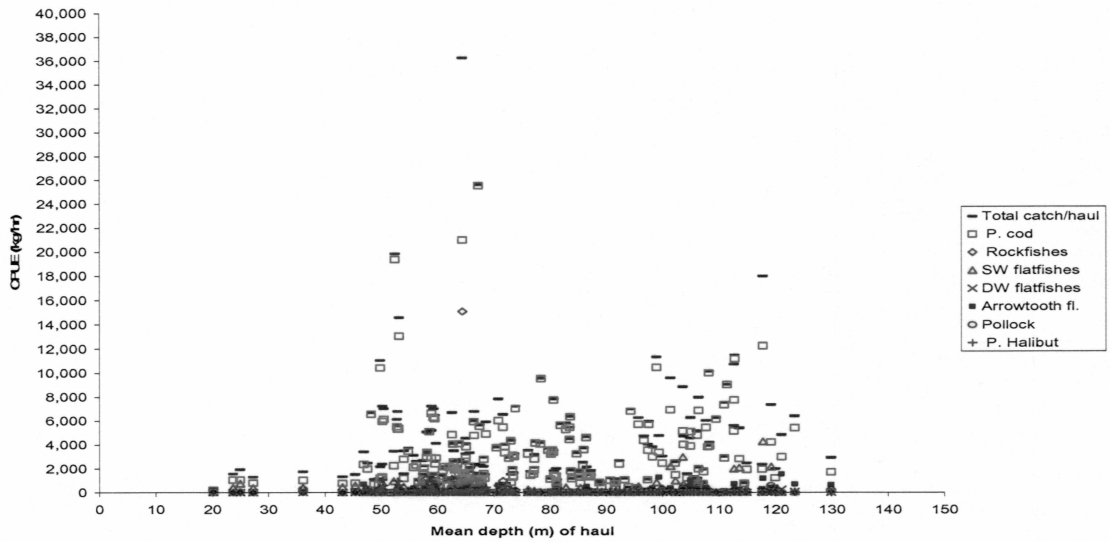


Figure 6a. CPUE of fishes within individual hauls that targeted Pacific cod versus mean depth of the haul. N = 209.

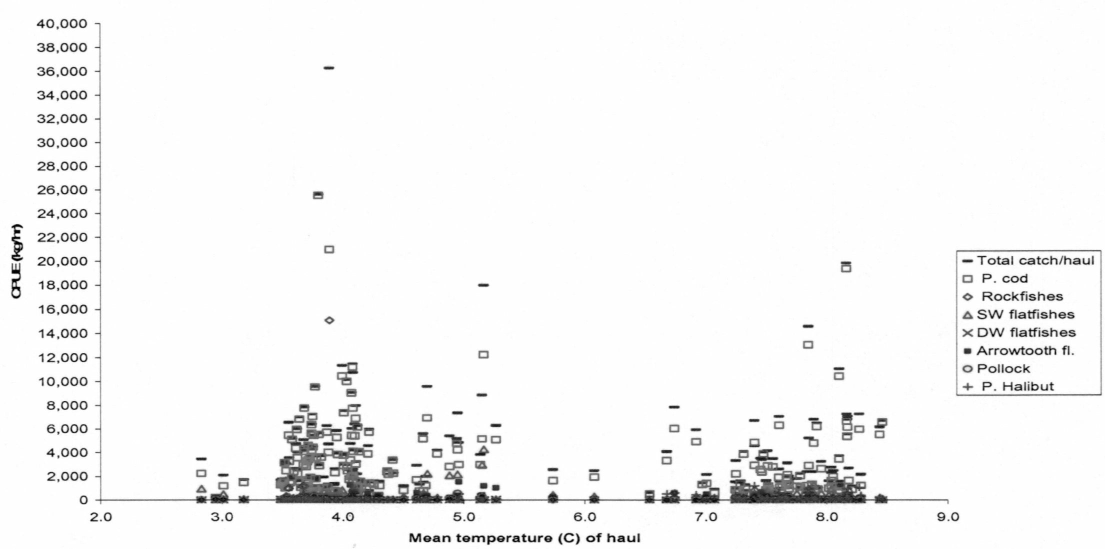


Figure 6b. CPUE of fishes within individual hauls that targeted Pacific cod versus mean temperature of the haul. N = 209.

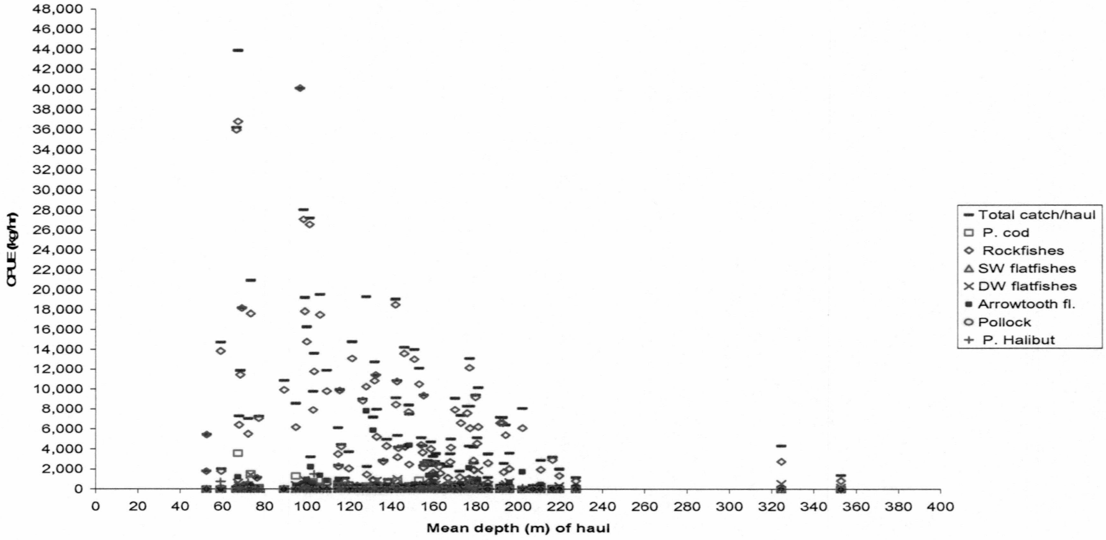


Figure 7a. CPUE of fishes within individual hauls that targeted rockfishes versus mean depth of the haul. N = 98.

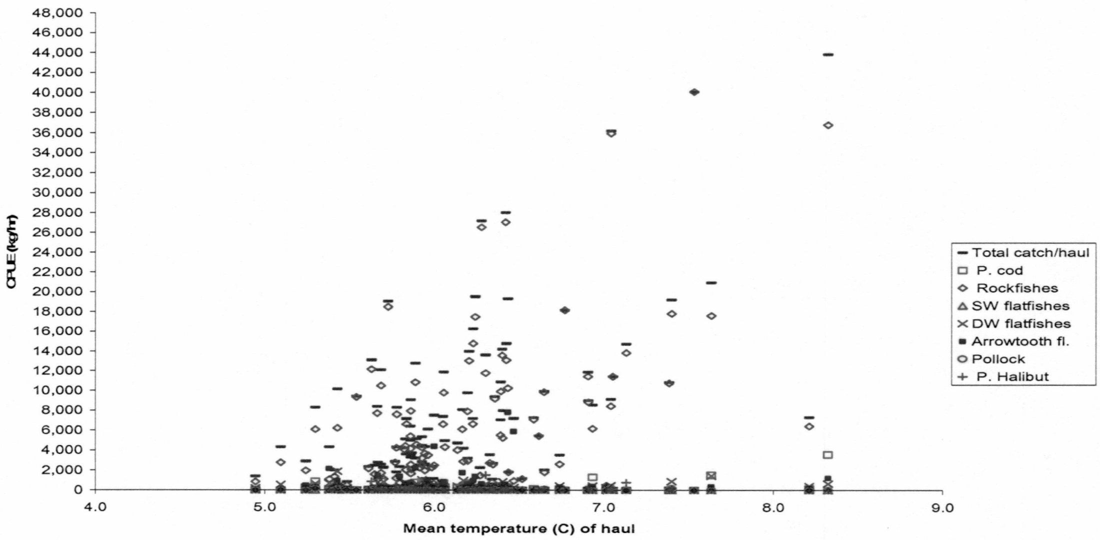


Figure 7b. CPUE of fishes within individual hauls that targeted rockfishes versus mean temperature of the haul. N = 98.

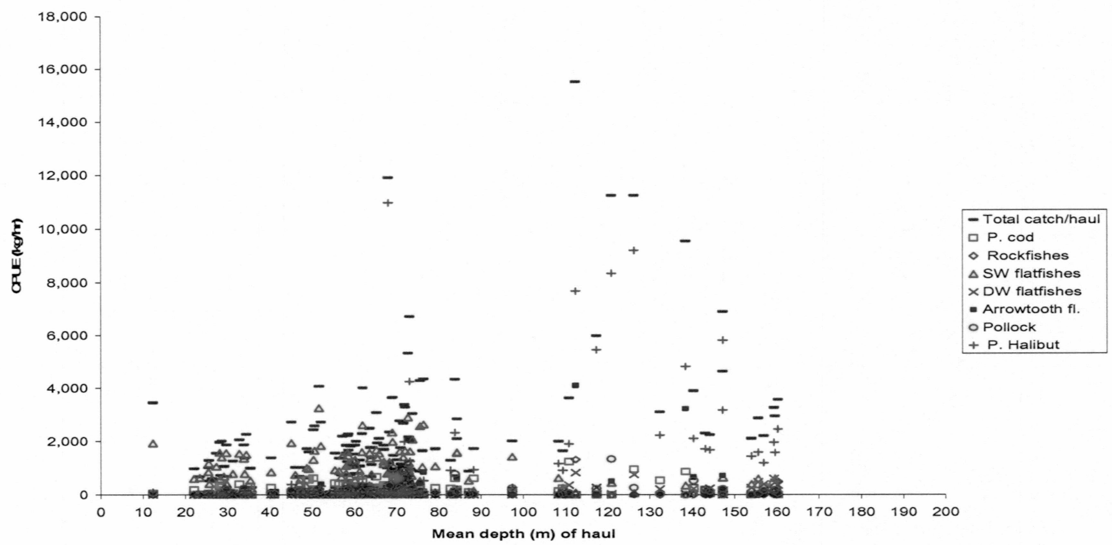


Figure 8a. CPUE of fishes within individual hauls that targeted SW flatfishes versus mean depth of the haul. N = 87.

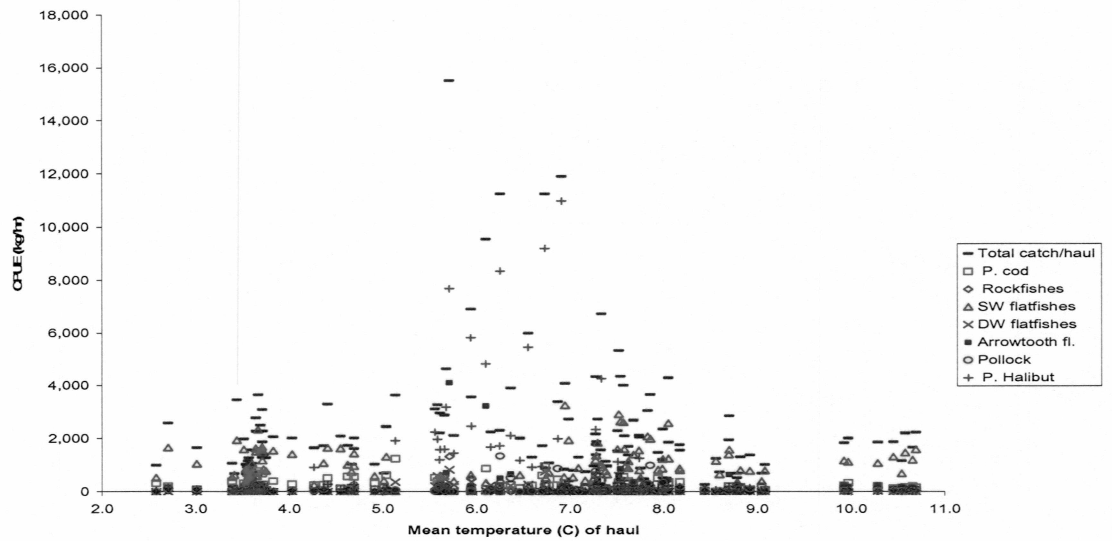


Figure 8b. CPUE of fishes within individual hauls that targeted SW flatfishes versus mean temperature of the haul. N = 87.

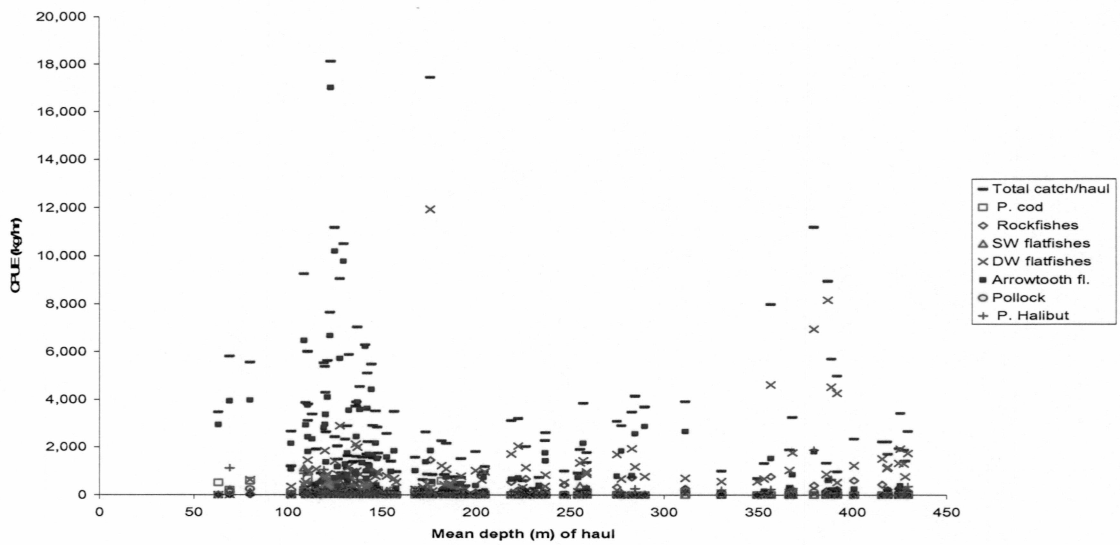


Figure 9a. CPUE of fishes within individual hauls that targeted DW flatfishes versus mean depth of the haul. N = 83.

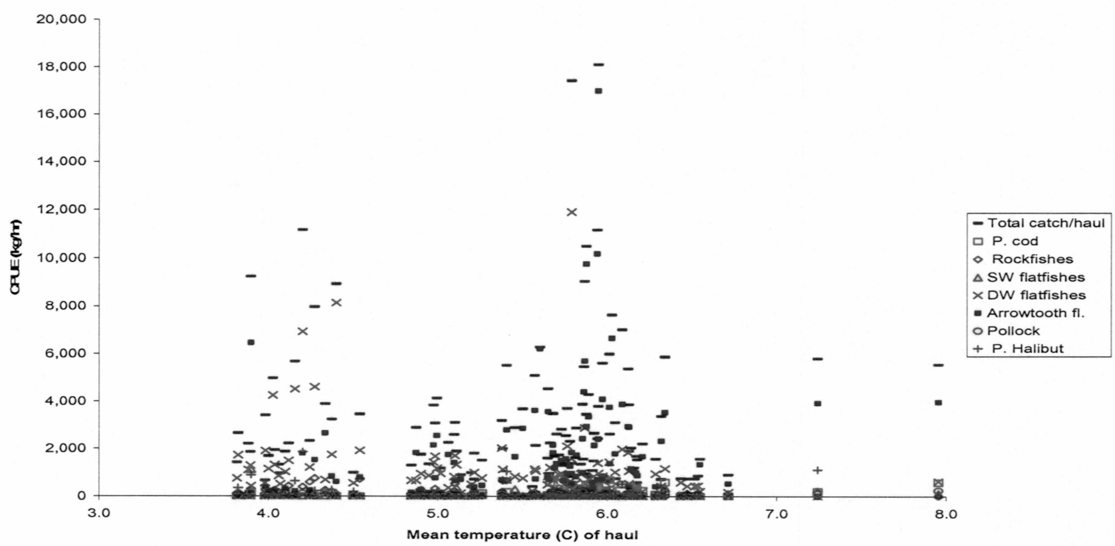


Figure 9b. CPUE of fishes within individual hauls that targeted DW flatfishes versus mean temperature of the haul. N = 83.

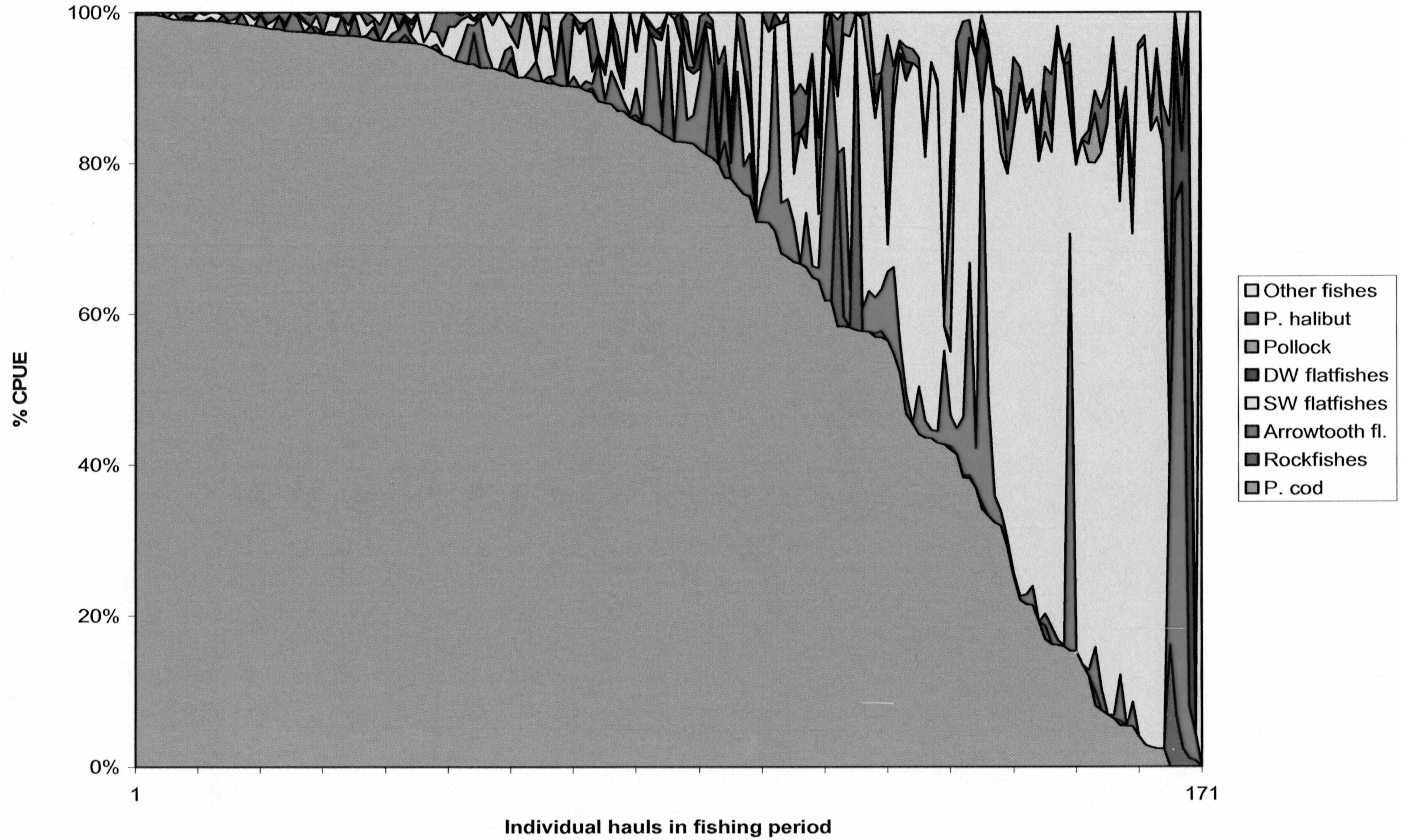
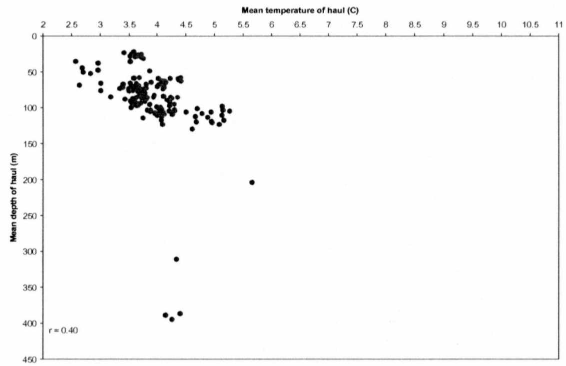
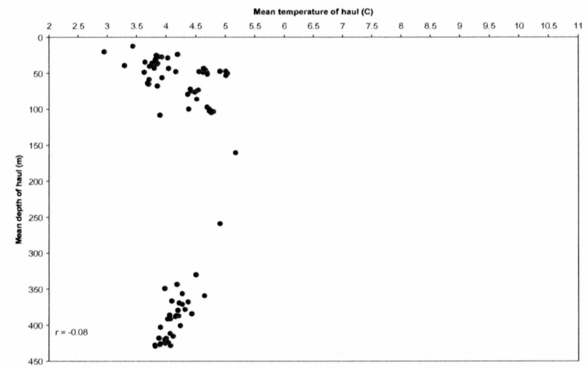


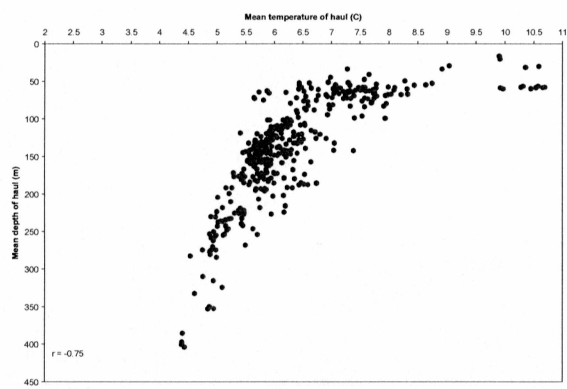
Figure 10. Percent CPUE of fishes within each haul made in January – March. N = 171.



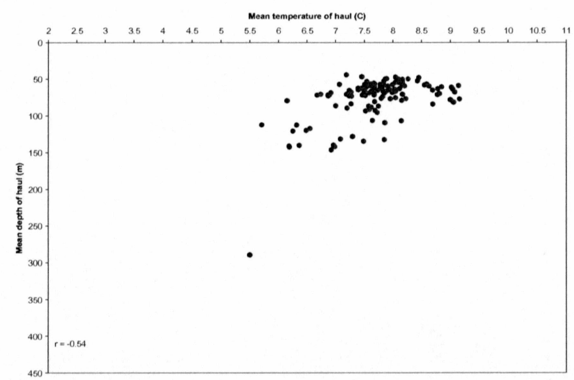
a. January – March. N = 171



b. April – June. N = 87



c. July – September. N = 410



d. October – November. N = 138

Figure 11. Mean depth versus mean temperature of individual hauls.

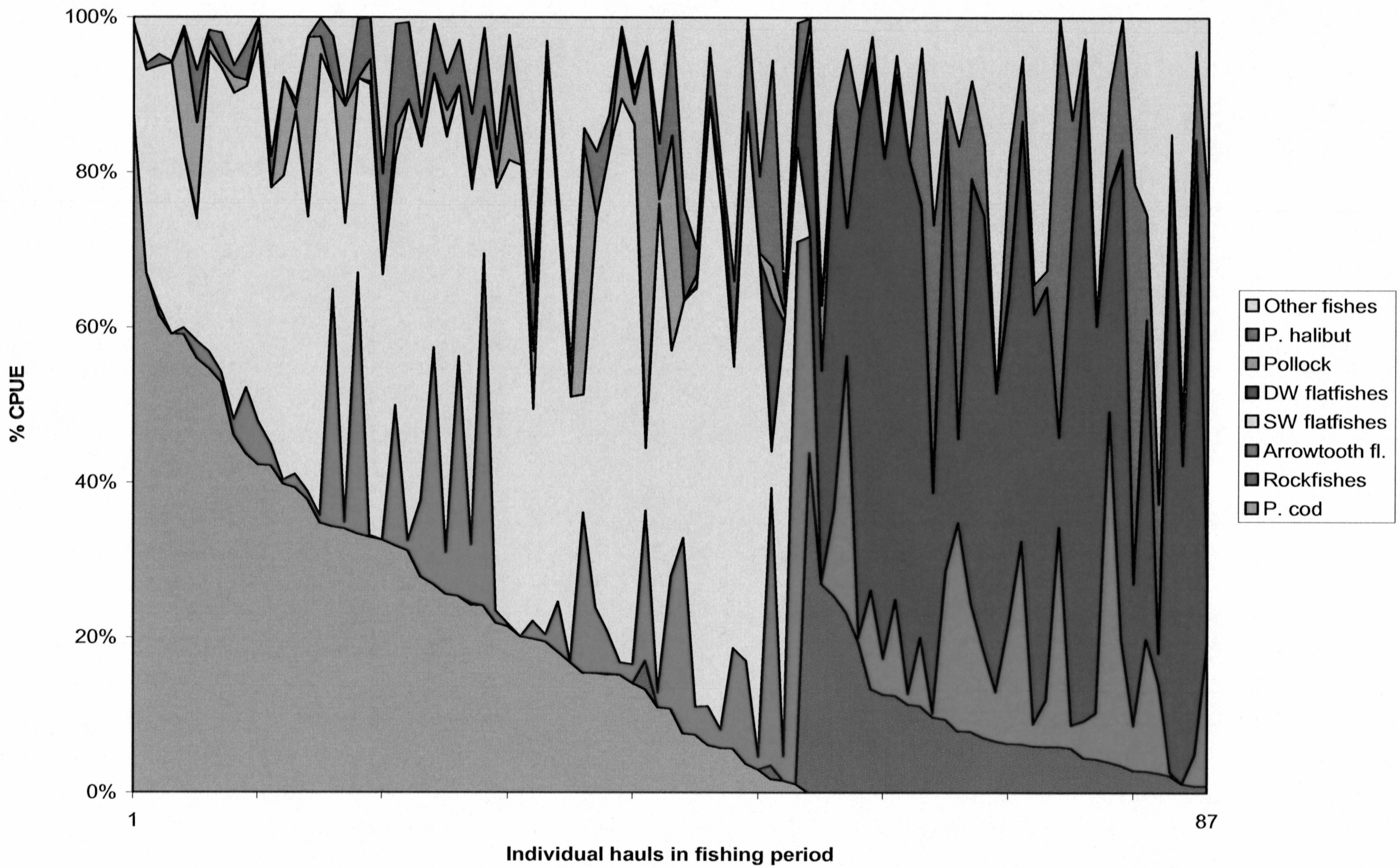


Figure 12. Percent CPUE of fishes within each haul made in April – June. N = 87.

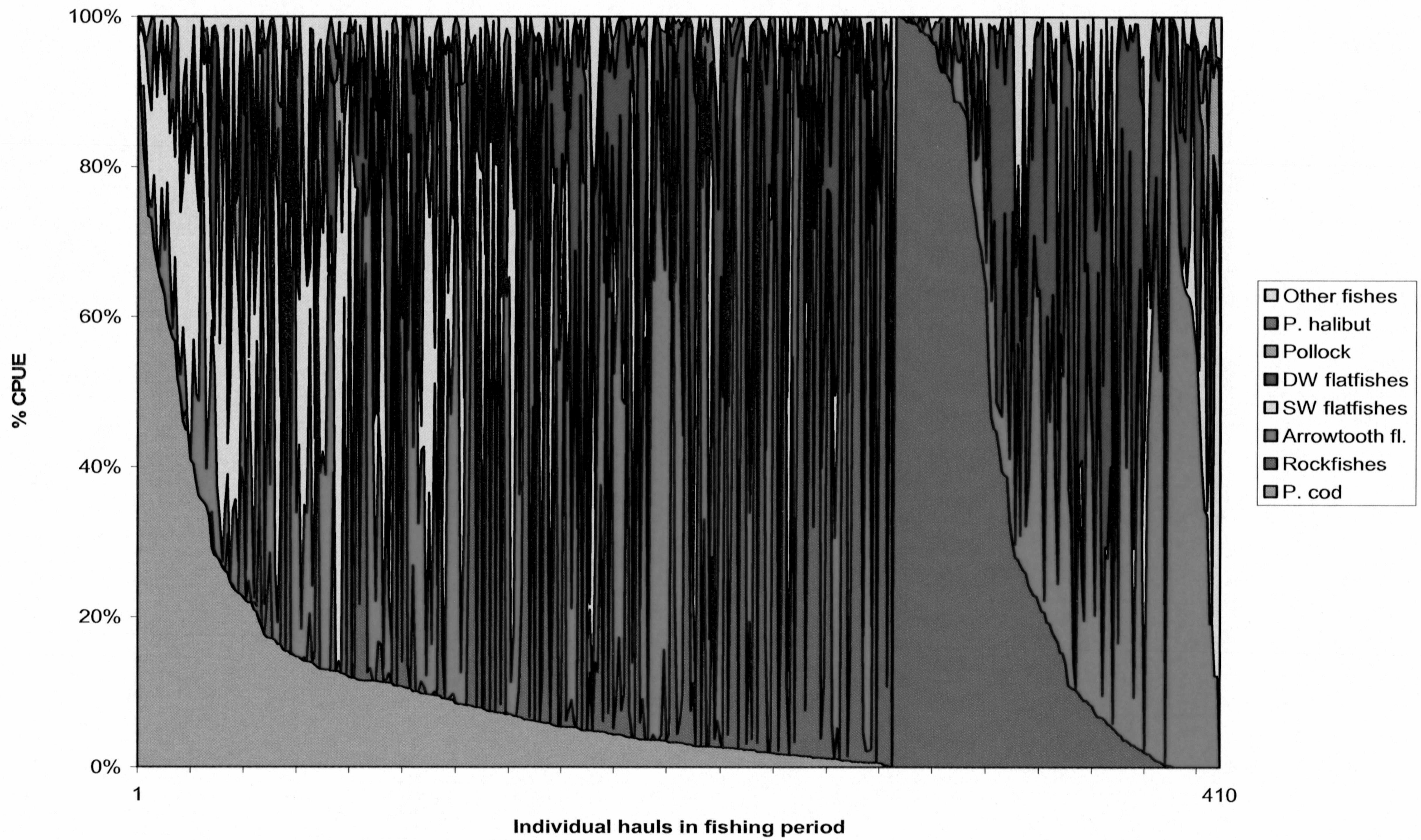


Figure 13. Percent CPUE of fishes within each haul made in July – September. N = 410 hauls.

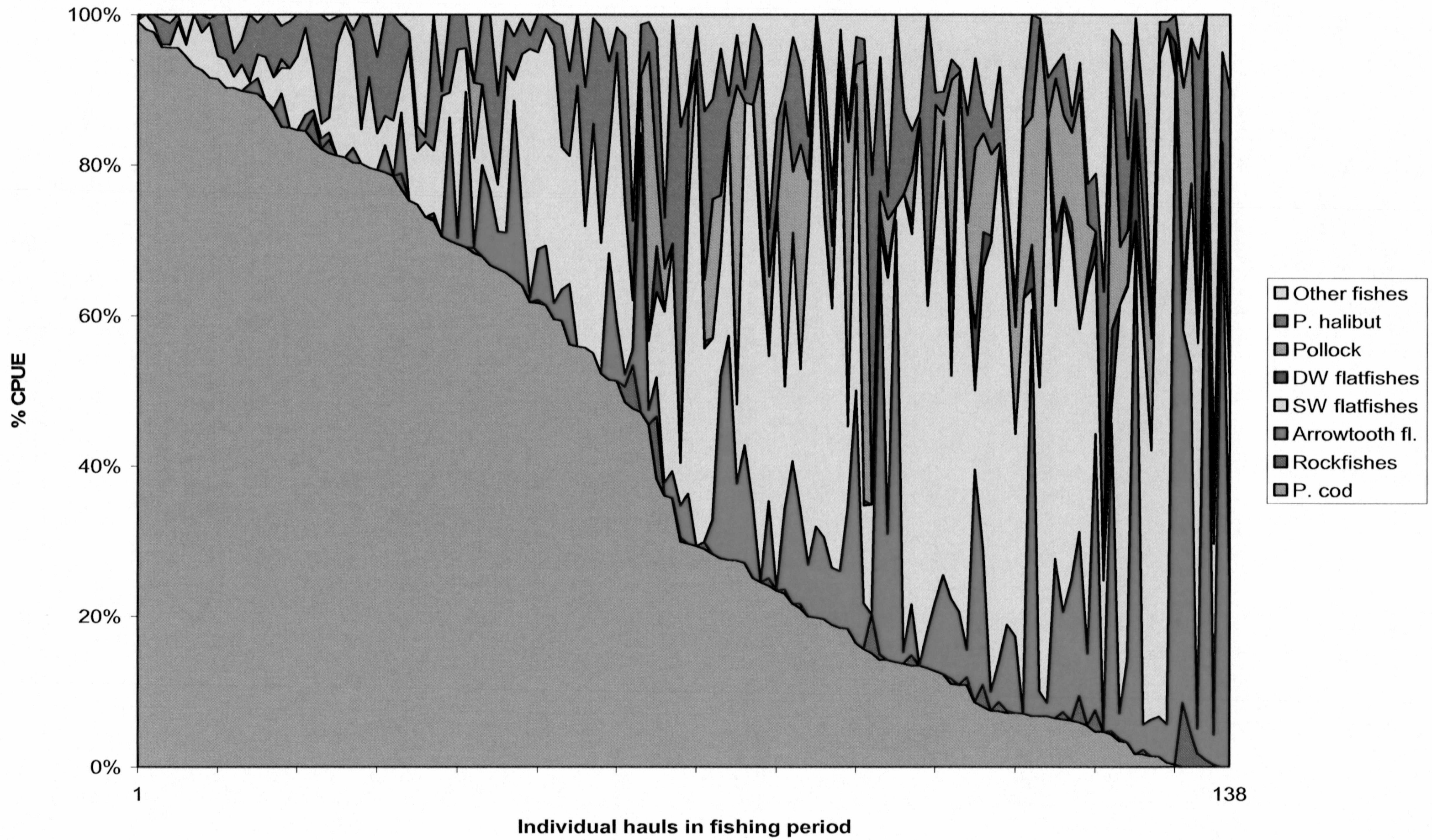


Figure 14. Percent CPUE of fishes within each haul made in October – November. N = 138 hauls

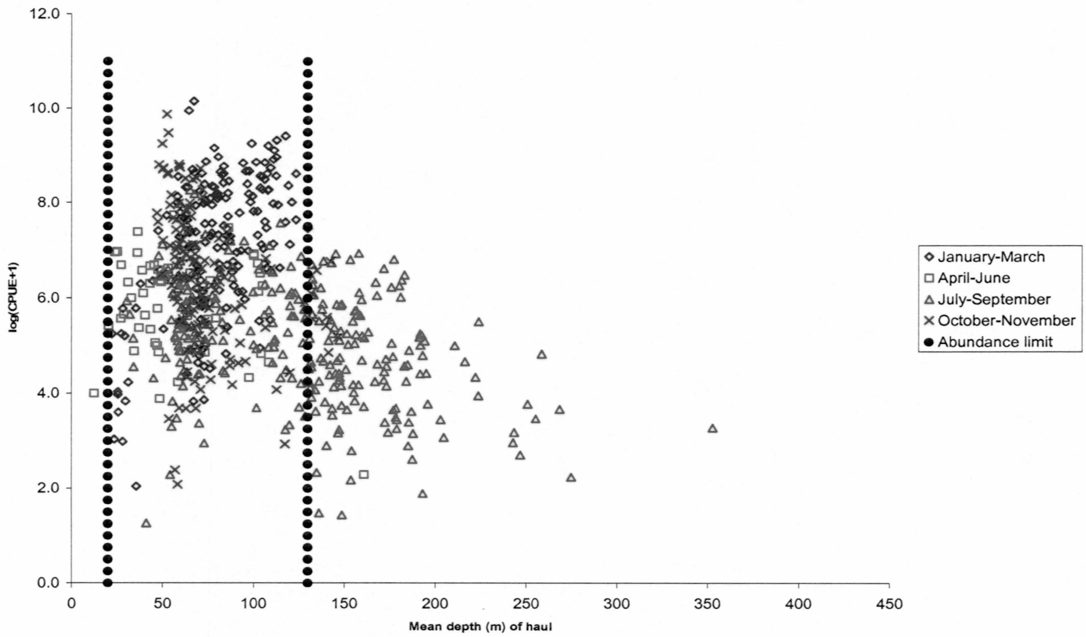


Figure 15a. LogCPUE of Pacific cod and mean depth of haul for all hauls where Pacific cod was captured. Vertical lines show upper and lower limits of abundance. N = 636.

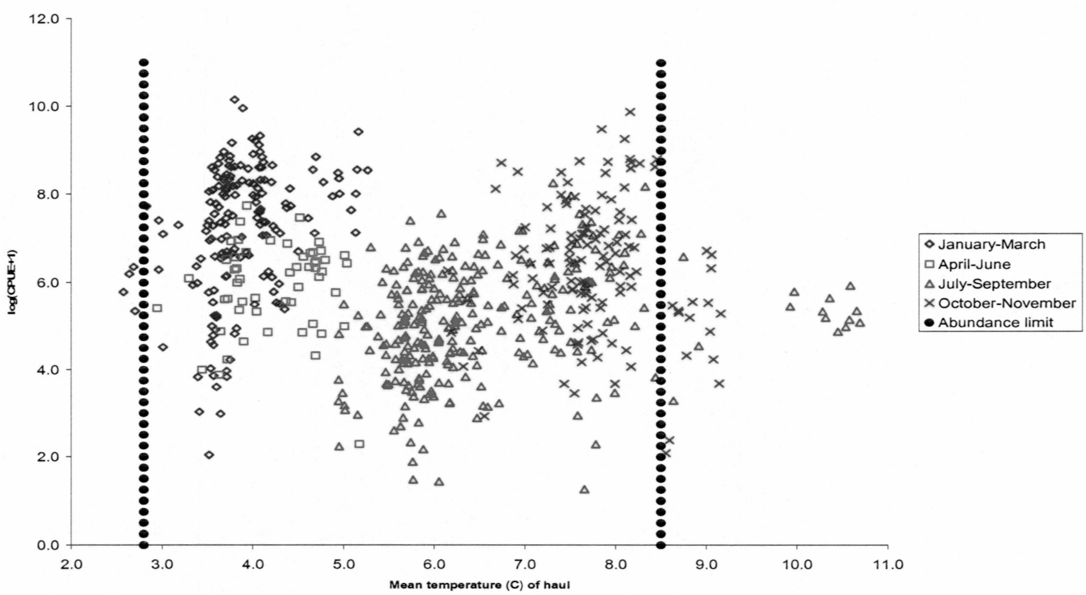


Figure 15b. LogCPUE of Pacific cod and mean temperature of haul for all hauls where Pacific cod was captured. Vertical lines show upper and lower limits of abundance. N = 636.

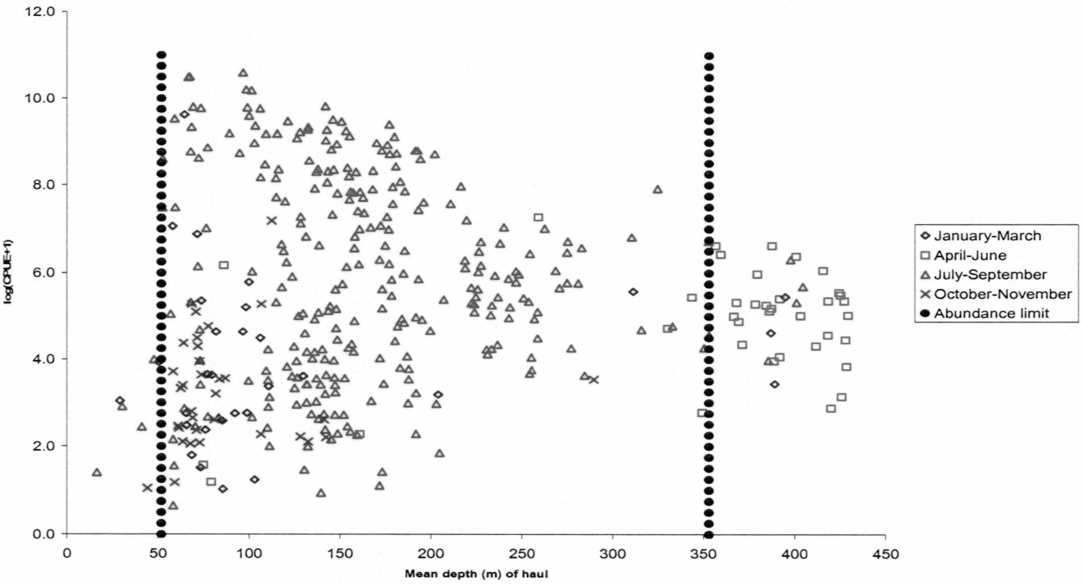


Figure 16a. LogCPUE of rockfishes and mean depth of haul for all hauls where rockfishes were captured. Vertical lines show upper and lower limits of abundance. N = 379.

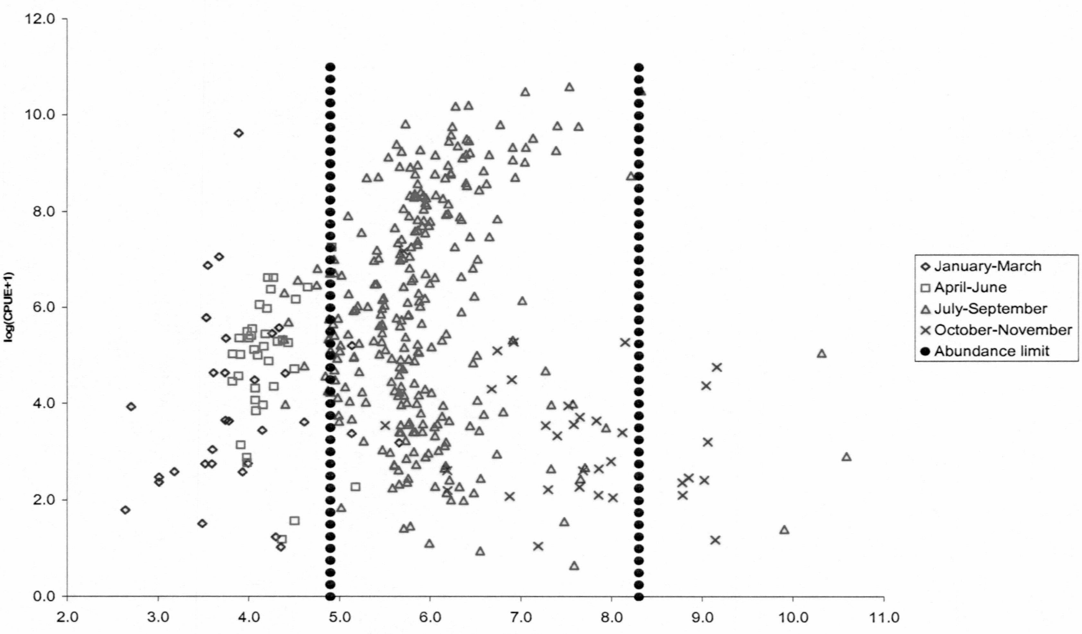


Figure 16b. LogCPUE of rockfishes and mean temperature of haul for all hauls where rockfishes were captured. Vertical lines show upper and lower limits of abundance. N = 379.

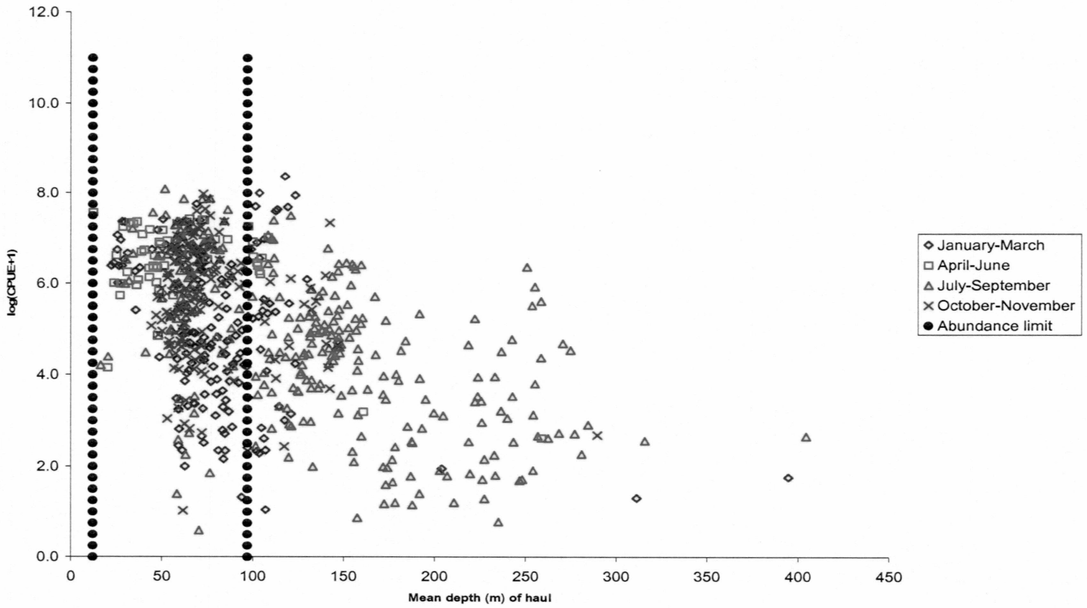


Figure 17a. LogCPUE of SW flatfishes and mean depth of haul for all hauls where SW flatfishes were captured. Vertical lines show upper and lower limits of abundance. N = 636.

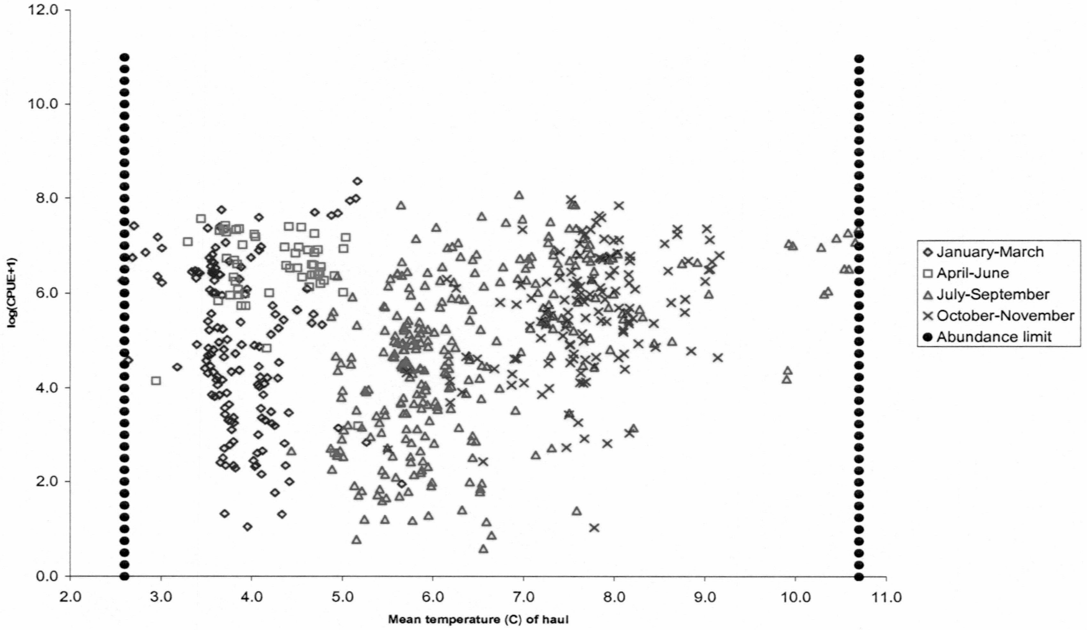


Figure 17b. LogCPUE of SW flatfishes and mean temperature of haul for all hauls where SW flatfishes were captured. Vertical lines show upper and lower limits of abundance. N = 636.

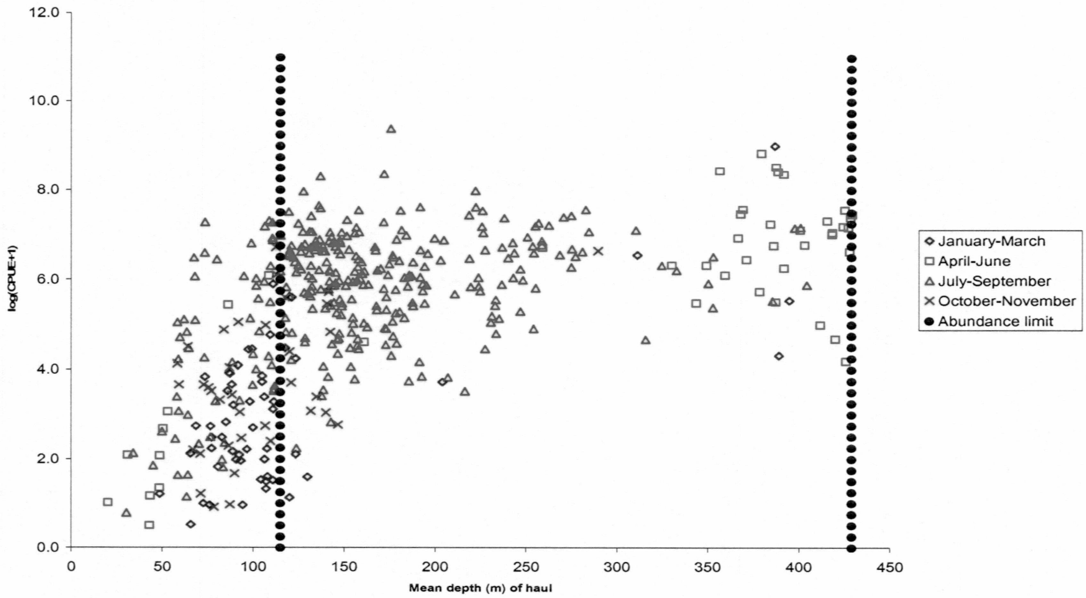


Figure 18a. LogCPUE of DW flatfishes and mean depth of haul for all hauls where DW flatfishes were captured. Vertical lines show upper and lower limits of abundance. N = 436.

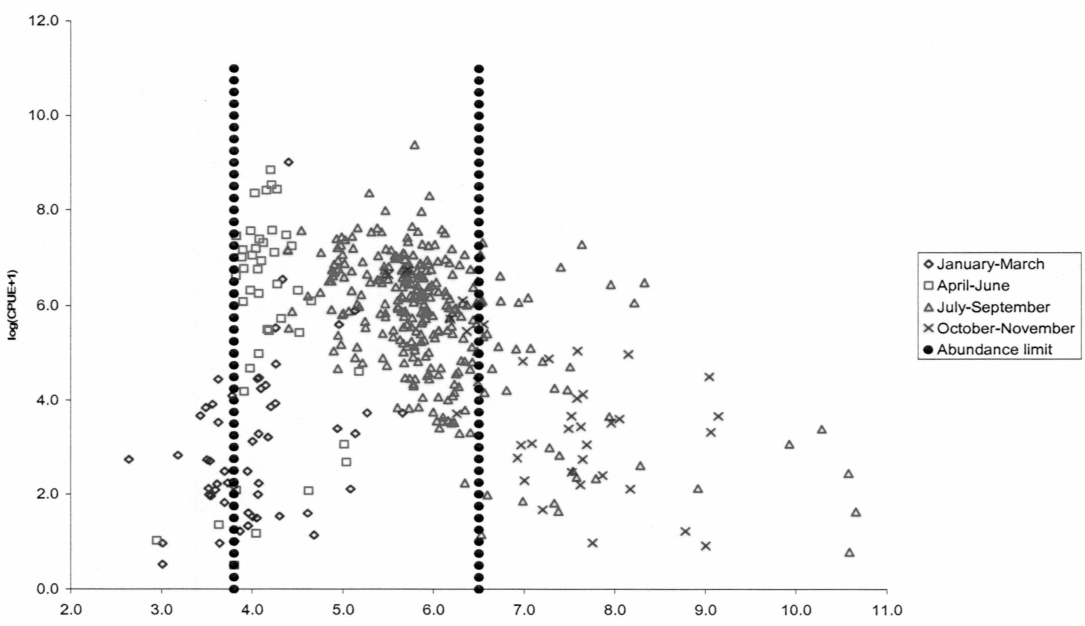


Figure 18b. LogCPUE of DW flatfishes and mean temperature of haul for all hauls where DW flatfishes were captured. Vertical lines show upper and lower limits of abundance. N = 436.

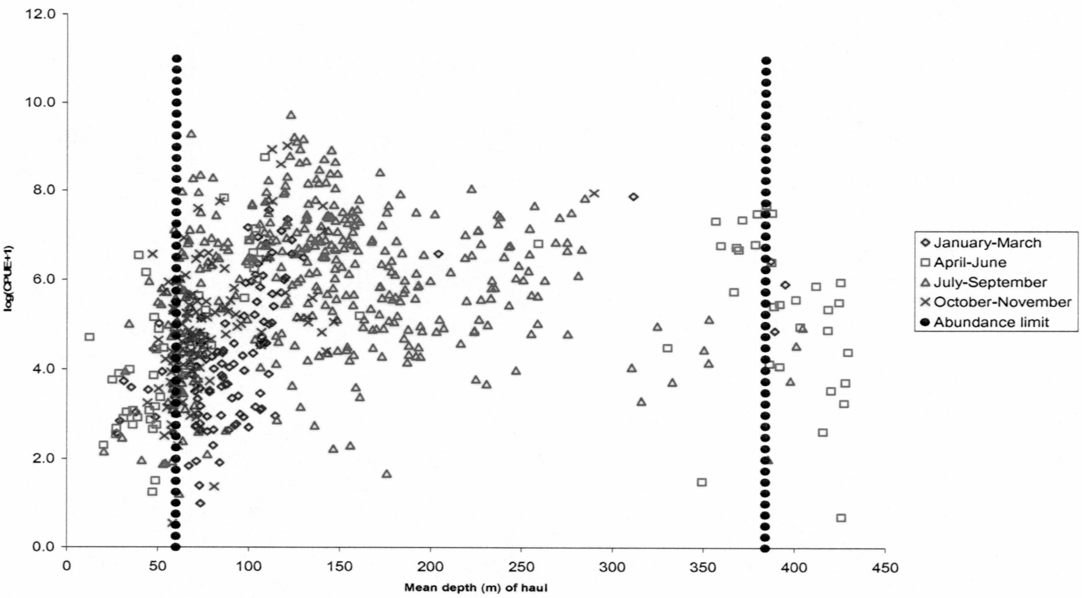


Figure 19a. LogCPUE of arrowtooth flounder and mean depth of haul for all hauls where arrowtooth flounder was captured. Vertical lines show upper and lower limits of abundance. N = 676.

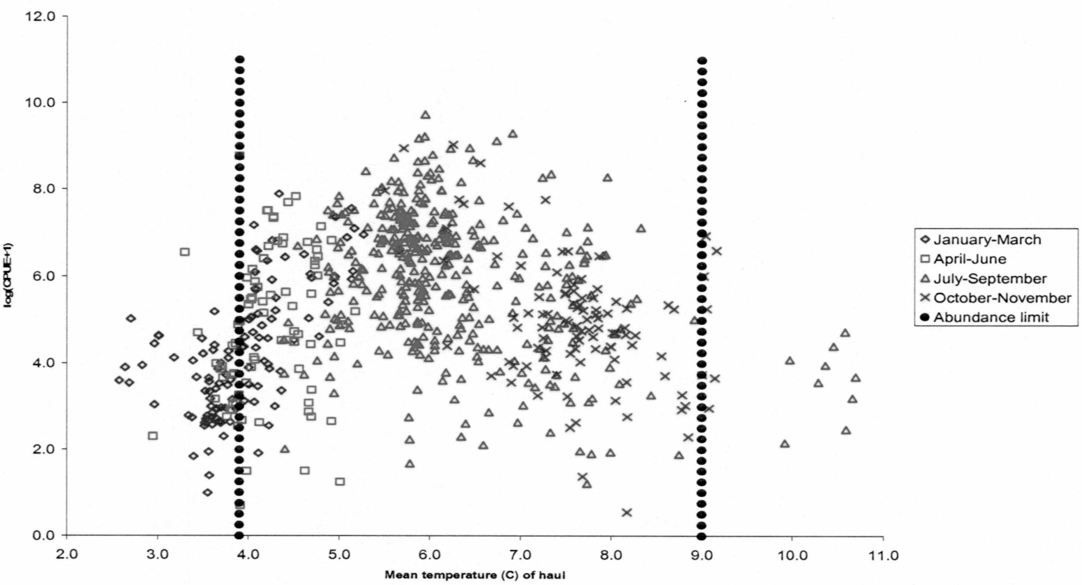


Figure 19b. LogCPUE of arrowtooth flounder and mean temperature of haul for all hauls where arrowtooth flounder was captured. Vertical lines show upper and lower limits of abundance. N = 676.

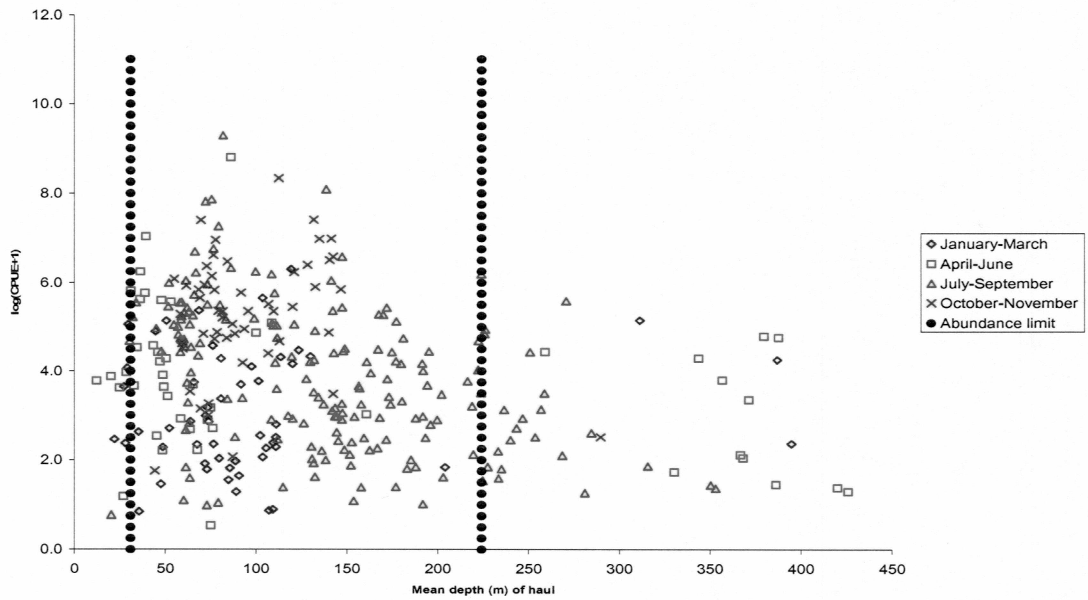


Figure 20a. LogCPUE of pollock and mean depth of haul for all hauls where pollock was captured. Vertical lines show upper and lower limits of abundance. N = 333.

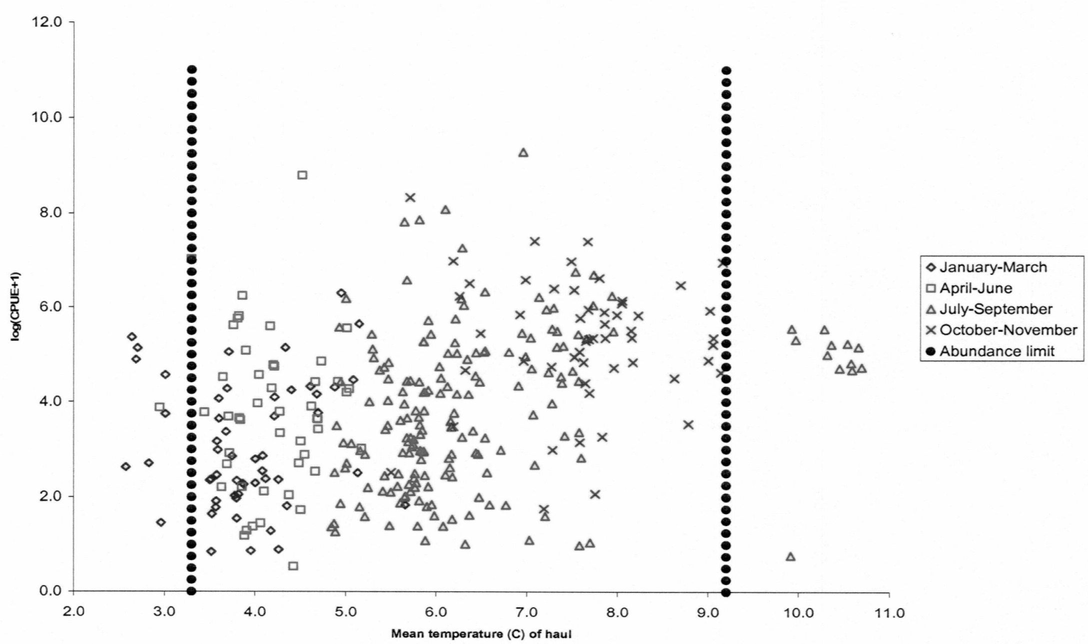


Figure 20b. LogCPUE of pollock and mean temperature of haul for all hauls where pollock was captured. Vertical lines show upper and lower limits of abundance. N = 333.

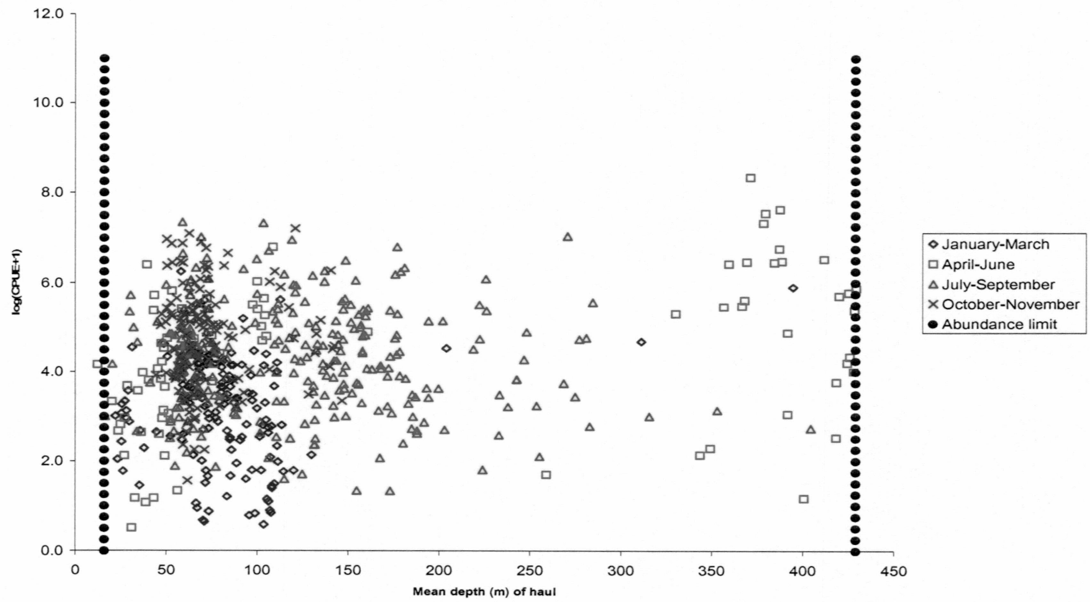


Figure 21a. LogCPUE of Pacific halibut and mean depth of haul for all hauls where Pacific halibut were captured. Vertical lines show upper and lower limits of abundance. N = 626.

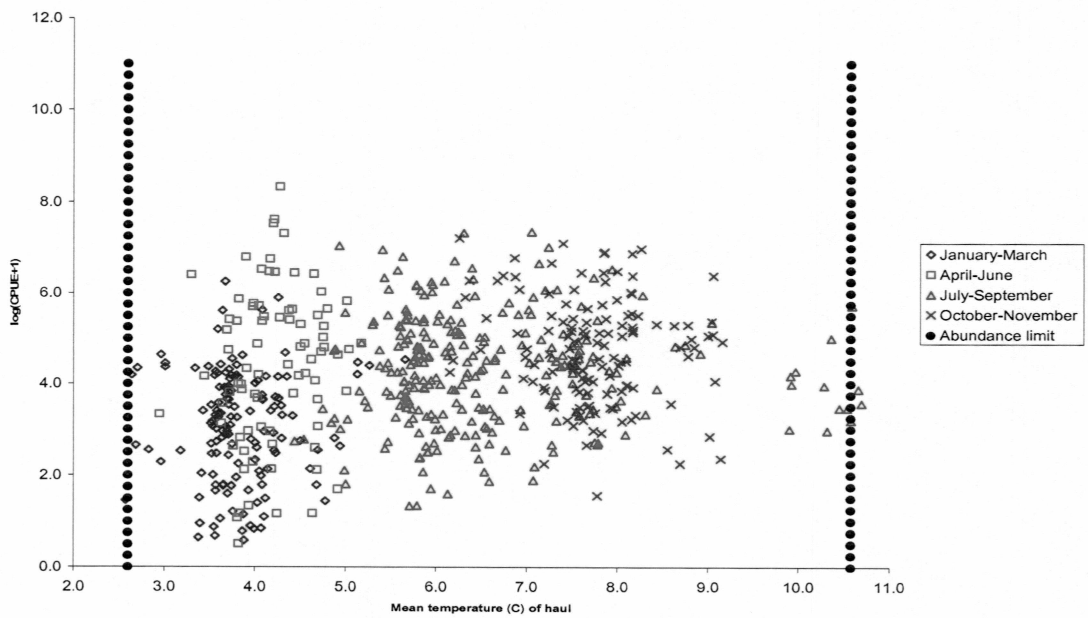


Figure 21b LogCPUE of Pacific halibut and mean temperature of haul for all hauls where Pacific halibut were captured. Vertical lines show upper and lower limits of abundance. N = 626.

Table 1. Dates commercial bottom trawl fisheries were open, dates fisheries were closed and reasons for closures during the period of this study.

Year	Date fishery opened	Date fishery closed	Fishery	Reason for closure
1995	4/01	4/22	Deep Water Complex *(1)*	Halibut bycatch limit
1995	Open	5/08	Shallow Water Complex *(2)*	Halibut bycatch limit
1995	6/01	6/05	Walleye pollock	Total Allowable Catch limit
1995	7/01	7/06	Walleye pollock	Total Allowable Catch limit
1995	7/01	7/17	Shallow Water Complex	Halibut bycatch limit
1995	7/01	7/21	Deep Water Complex	Halibut bycatch limit
1995	7/03	7/21	Rockfish	Total Allowable Catch limit
1995	10/01	10/04	Walleye pollock	Total Allowable Catch limit
1995	10/01	10/11	Pacific cod	Total Allowable Catch limit
1995	10/01	10/23	Deep Water Complex	Halibut bycatch limit
1995	10/01	10/23	Shallow Water Complex	Halibut bycatch limit
1996	1/20	1/23	Walleye pollock	Total Allowable Catch limit
1996	1/29	2/02	Walleye pollock	Total Allowable Catch limit
1996	1/20	Open	Shallow Water Complex	Did not close
1996	1/20	3/21	Deep Water Complex	Halibut bycatch limit
1996	1/20	3/18	Pacific cod	Total Allowable Catch limit
1996	4/01	4/15	Deep Water Complex	Halibut bycatch limit
1996	Open	5/13	Shallow Water Complex	Halibut bycatch limit
1996	6/01	6/01	Walleye pollock	Total Allowable Catch limit
1996	4/1	5/05	Pacific cod	Total Allowable Catch limit
1996	9/01	9/19	Walleye pollock	Total Allowable Catch limit
1996	7/01	8/05	Shallow Water Complex	Halibut bycatch limit
1996	7/01	8/07	Deep Water Complex	Halibut bycatch limit
1996	7/01	7/22	Rockfish	Overfishing
1997	9/01	9/21	Walleye pollock	Total Allowable Catch limit
1997	7/01	8/11	Shallow Water Complex	Halibut bycatch limit
1997	7/01	7/20	Deep Water Complex	Total Allowable Catch limit
1997	7/01	7/25	Rockfish	Total Allowable Catch limit
1997	10/01	11/26	Shallow Water Complex	Halibut bycatch limit
1997	10/01	10/27	Pacific cod	Total Allowable Catch limit

(1) Deep Water Complex = sablefish, Rockfish, rex sole, arrowtooth flounder, and deep-water flatfish

(2) Shallow Water Complex = Walleye pollock, Pacific cod, shallow-water flatfish, flathead sole, Atka mackerel, and "other" species

Table 2. Total weight of species captured, number of hauls in which individual species were captured, and number of haul in which species or species complex was targeted for commercially important species caught by bottom trawl gear. Prohibited species are indicated by (P). Weight of all species captured is 6,057.56 t in 874 hauls. Species are listed in order by weight of species and by species complex captured. Total weight of species listed is 6,048.01 t. Non-commercially important species are not listed. Hauls where CPUE data were not available are included. Bold type indicates the species or species complexes included in analysis.

Species or species complex	Total weight of species or species complex captured (t)	Number of hauls in which species was captured	Number of hauls in which species or species complex was captured as the targeted fish
Pacific cod	**1,815.22**	**680**	**209**
All rockfishes:	**1,149.03**	**419**	**98**
Pacific Ocean Perch	723.96	244	
Northern rockfish	179.63	150	
Light dusky rockfish	127.67	170	
Shortspine thornyhead	45.62	130	
Shortraker rockfish	17.90	45	
Harlequin rockfish	16.06	36	
Sharpchin rockfish	11.16	40	
Redstripe rockfish	7.30	4	
Rockfish, spp.	4.38	5	
Shortraker/rougheye rockfish	3.35	2	
Yelloweye rockfish	3.25	24	
Thornyhead, spp.	2.95	6	
Black rockfish	2.10	3	
Longspine thornyhead	1.30	3	
Splitnose rockfish	1.08	8	
Red banded rockfish	0.95	21	
Silvergrey rockfish	0.37	5	
Arrowtooth flounder	**1,051.66**	**715**	**0**
Flatfish in Shallow Water Complex:	**804.16**	**683**	**87**
Rock sole	488.59	459	
Flathead sole	135.60	470	
Butter sole	121.49	221	
Starry flounder	25.51	120	
Sand sole	10.00	32	
English sole	7.35	69	
Yellowfin sole	5.69	44	
Alaska plaice	4.91	46	
Southern rock sole	4.26	17	
Northern rock sole	0.77	7	

(Table 2 continued)

Flatfish in Deep Water Complex:	**373.17**	**455**	**83**
Dover sole	234.98	311	
Rex sole	138.19	421	
Walleye pollock	**326.41**	**355**	**0**
Pacific halibut (P)	**233.46**	**669**	**0**
Sablefish	184.79	279	
Skate	95.67	306	
Shark	5.77	50	
Crab, Tanner Bairdi (P)	3.19	172	
Octopus	2.85	18	
Squid	1.15	57	
Chum salmon (Dog) (P)	0.75	30	
King salmon (Chinook) (P)	0.50	13	
Herring, Pacific (P)	0.11	12	
Salmon, spp. (P)	0.05	2	
Crab, Tanner, spp. (P)	0.02	5	
Crab, king golden (P)	0.01	5	
Crab, king, red (P)	0.01	5	
Crab, king, Couesi (P)	<0.01	4	
Crab, king, spp. (P)	<0.01	2	
Pink salmon (Humpback) (P)	<0.01	2	

Table 3. Number, mean depth, and mean temperature of hauls where Pacific cod was captured and hauls that targeted this species. NS = no sample.

	All hauls capturing Pacific cod				All hauls targeting Pacific cod		
Months	Total no. of hauls	No. of hauls	Mean (sd) depth of hauls (m)	Mean (sd) temperature of haul (°C)	No. of hauls	Mean (sd) depth of hauls (m)	Mean (sd) temperature of haul (°C)
1995							
January-March	NS	NS			NS		
April-June	15	10	98(15)	4.5(0.4)	1	56	3.9
July-September	82	48	121(15)	6.3(0.7)	NS		
October-November	36	35	65(15)	7.9(0.4)	13	54(5)	7.9(0.3)
Total	*133*	*93*			*14*		
1996							
January-March	171	165	81(24)	3.9(0.5)	123	88(18)	4.0(0.4)
April-June	72	44	50(24)	4.2(0.5)	7	31(10)	4.0(0.6)
July-September	211	144	138(49)	6.1(0.8)	2	76(16)	6.4(0.9)
October-November	NS	NS			NS		
Total	*454*	*353*			*132*		
1997							
January-March	NS	NS			NS		
April-June	NS	NS			NS		
July-September	117	94	100(56)	7.3(1.4)	15	63(4)	7.4(0.6)
October-November	102	96	76(24)	7.7(0.7)	48	63(8)	7.7(0.4)
Total	*219*	*190*			*63*		
All years							
January-March	171	165	81(24)	3.9(0.5)	123	88(18)	4.0(0.4)
April-June	87	54	59(29)	4.2(0.5)	8	35(13)	4.0(0.5)
July-September	410	286	123(54)	6.5(1.1)	17	65(7)	7.3(0.7)
October-November	138	131	73(23)	7.8(0.6)	61	61(8)	7.7(0.4)
Total	*806*	*636*			*209*		

Table 4. Number, mean depth, and mean temperature of hauls where SW flatfishes were captured and of hauls that targeted SW flatfishes. NS = no sample.

		All hauls capturing SW flatfishes			All hauls targeting SW flatfishes		
Months	Total no. of hauls	No. of hauls	Mean (sd) depth of hauls (m)	Mean (sd) temperature of haul (^{0}C)	No. of hauls	Mean (sd) depth of hauls (m)	Mean (sd) temperature of haul (^{0}C)
1995							
January-March	NS	NS			NS		
April-June	15	11	113(51)	4.6(0.4)	NS		
July-September	82	68	138(57)	6.0(0.6)	3	87(41)	6.2(0.9)
October-November	36	36	66(17)	7.8(0.5)	5	75(22)	7.7(1.2)
Total	*133*	*115*			*8*		
1996							
January-March	171	145	83(42)	3.9(0.5)	26	53(28)	3.6(0.4)
April-June	72	44	50(24)	4.2(0.5)	8	57(20)	4.6(0.3)
July-September	211	146	151(66)	6.0(1.0)	13	114(44)	6.4(0.8)
October-November	NS	NS			NS		
Total	*454*	*335*			*47*		
1997							
January-March	NS	NS			NS		
April-June	NS	NS			NS		
July-September	117	84	88(51)	7.5(1.4)	17	99(39)	6.8(0.8)
October-November	102	102	78.9(33)	7.7(0.7)	15	84(28)	7.6(0.9)
Total	*219*	*186*			*32*		
All years							
January-March	171	145	83(42)	3.9(0.5)	26	53(28)	3.6(0.4)
April-June	87	55	63(40)	4.3(0.5)	8	57(20)	4.6(0.3)
July-September	410	298	130(66)	6.4(1.2)	33	104(41)	6.6(0.8)
October-November	138	138	76(30)	7.7(0.7)	20	82(27)	7.6(0.9)
Total	*806*	*636*			*87*		

Table 5. Number, mean depth, and mean temperature of hauls where Pacific halibut was captured. No hauls targeted Pacific halibut. NS = no sample.

Months	Total no. of hauls	No. of hauls	Mean (sd) depth of hauls (m)	Mean (sd) temperature of haul (^{0}C)
1995	NS	NS		
January-March	NS	NS		
April-June	15	14	167(118)	4.5(0.3)
July-September	82	66	138(61)	6.0(0.6)
October-November	36	73	84(47)	7.6(1.4)
Total	*133*	*153*		
1996				
January-March	171	140	83(42)	3.8(0.5)
April-June	72	67	178(169)	4.2(0.4)
July-September	211	129	139(64)	6.2(1.0)
October-November	NS	NS		
Total	*454*	*336*		
1997				
January-March	NS	NS		
April-June	NS	NS		
July-September	117	78	84(47)	7.6(1.4)
October-November	102	97	77(24)	7.7(0.7)
Total	*219*	*175*		
All years				
January-March	171	140	83(42)	3.8(0.5)
April-June	87	81	176(161)	4.2(0.4)
July-September	410	273	124(64)	6.5(1.2)
October-November	138	132	73(23)	7.7(0.6)
Total	*806*	*626*		

Table 6. Number, mean depth, and mean temperature of hauls where arrowtooth flounder was captured. No hauls targeted arrowtooth flounder. NS = no sample.

Months	Total no. of hauls	No. of hauls	Mean (sd) depth of hauls (m)	Mean (sd) temperature of haul (^{0}C)
1995				
January-March	NS	NS		
April-June	15	13	181(128)	4.6(0.3)
July-September	82	78	141(61)	6.1(0.7)
October-November	36	29	69(17)	7.8(0.6)
Total	*133*	*120*		
1996				
January-March	171	113	98(58)	3.9(0.6)
April-June	72	66	191(171)	4.2(0.4)
July-September	211	202	160(70)	5.9(0.8)
October-November	NS	NS		
Total	*454*	*381*		
1997				
January-March	NS	NS		
April-June	NS	NS		
July-September	117	104	114(64)	7.0(1.3)
October-November	102	71	85(36)	7.6(0.8)
Total	*219*	*175*		
All years				
January-March	171	113	98(58)	3.9(0.6)
April-June	87	79	190(164)	4.2(0.4)
July-September	410	384	144(69)	6.2(1.1)
October-November	138	100	81(32)	7.6(0.8)
Total	*806*	*676*		

Table 7. Number, mean depth, and mean temperature of hauls where rockfishes were captured and hauls that targeted rockfishes. NS = no sample.

		All hauls capturing rockfishes			All hauls targeting rockfishes		
Months	Total no. of hauls	No. of hauls	Mean (sd) depth of hauls (m)	Mean (sd) temperature of haul (^{0}C)	No. of hauls	Mean (sd) depth of hauls (m)	Mean (sd) temperature of haul (^{0}C)
1995							
January-March	NS	NS			NS		
April-June	15	4	341(60)	4.5(0.3)	NS		
July-September	82	55	154(62)	6.0(0.7)	11	53(14)	6.9(0.6)
October-November	36	6	76(19)	7.4(0.9)	NS		
Total	*133*	*65*			*11*		
1996							
January-March	171	31	123(102)	3.9(0.7)	NS		
April-June	72	33	359(102)	4.2(0.3)	NS		
July-September	211	175	170(69)	5.8(0.7)	51	140(42)	6.0(0.5)
October-November	NS	0			NS		
Total	*454*	*239*			*51*		
1997							
January-March	NS	NS			NS		
April-June	NS	NS			NS		
July-September	117	48	159(66)	6.4(1.0)	36	145(55)	6.4(0.6)
October-November	102	27	90(48)	7.7(1.0)	NS		
Total	*219*	*75*			*36*		
All years							
January-March	171	31	123(102)	3.9(0.7)	NS		
April-June	87	37	357(98)	4.2(0.3)	NS		
July-September	410	278	165(68)	5.9(0.8)	98	132(53)	6.3(0.6)
October-November	138	33	87(44)	7.7(1.0)	NS		
Total	*806*	379			*98*		

Table 8. Number, mean depth, and mean temperature of hauls where DW flatfishes were captured and hauls that targeted DW flatfishes. NS = no sample.

	All hauls capturing DW flatfishes				All hauls targeting DW flatfishes		
Months	Total no. of hauls	No. of hauls	Mean (sd) depth of hauls (m)	Mean (sd) temperature of haul (^{0}C)	No. of hauls	Mean (sd) depth of hauls (m)	Mean (sd) temperature of haul (^{0}C)
1995							
January-March	NS	NS			NS		
April-June	15	5	294(116)	4.4(0.4)	1	108	3.9
July-September	82	68	153(56)	6.0(0.7)	27	145(48)	5.8(0.4)
October-November	36	8	86(26)	7.4(1.7)	1	113	6.3
Total	*133*	*81*			*29*		
1996							
January-March	171	54	118(76)	4.0(0.6)	4	323(87)	4.6(0.7)
April-June	72	39	309(152)	4.1(0.4)	15	398(27)	4.1(0.2)
July-September	211	179	170(67)	5.8(0.7)	23	179(62)	5.6(0.5)
October-November	NS	28	109(44)	7.4(0.9)	NS		
Total	*454*	*300*			*42*		
1997							
January-March	NS	NS			NS		
April-June	NS	NS			NS		
July-September	117	55	149(66)	6.6(1.4)	11	124(39)	6.3(0.7)
October-November	102	28	109(44)	7.4(0.9)	1	290	5.5
Total	*219*	*83*			*12*		
All years							
January-March	171	54	118(76)	4.0(0.6)	4	323(87)	4.6(0.7)
April-June	87	44	307(147)	4.2(0.4)	16	380(77)	4.1(0.2)
July-September	410	302	162(65)	6.0(0.9)	61	154(56)	5.8(0.5)
October-November	138	36	104(41)	7.4(0.9)	2	201(125)	5.9(0.6)
Total	*806*	*436*			*83*		

Table 9. Analysis of Variance of CPUE (kg/hour) of Pacific cod with temperature and depth of hauls. N = number of hauls. Alpha = 0.05.

	All hauls that captured Pacific cod			All hauls that targeted Pacific cod		
January - November	**N = 636**		**Mean CPUE = 1251**	**N = 209**		**Mean CPUE = 3193**
	DF	**F Value**	**p value**	**DF**	**F Value**	**p value**
Model	3	31.57	*<0.0001*	3	3.01	*0.0310*
Depth	1	37.30	*<0.0001*	1	6.94	*0.0091*
Temperature	1	23.11	*<0.0001*	1	5.06	*0.0255*
Depth*Temperature	1	48.79	*<0.0001*	1	5.58	*0.0191*
January - March	**N = 165**		**Mean CPUE = 2826**	**N = 123**		**Mean CPUE = 3669**
	DF	**F Value**	**p value**	**DF**	**F Value**	**p value**
Model	3	4.67	*0.0037*	3	0.73	0.5339
Depth	1	1.24	0.2670	1	0.98	0.3244
Temperature	1	1.42	0.2357	1	0.65	0.4223
Depth*Temperature	1	0.62	0.4334	1	1.04	0.3090
April - June	**N = 54**		**Mean CPUE = 540**	**N = 8**		**Mean CPUE = 1005**
	DF	**F Value**	**p value**	**DF**	**F Value**	**p value**
Model	3	0.48	0.6987	3	10.25	*0.0239*
Depth	1	0.58	0.4502	1	17.03	*0.0145*
Temperature	1	1.23	0.2720	1	9.20	*0.0386*
Depth*Temperature	1	0.76	0.3886	1	13.35	*0.0217*
July - September	**N =286**		**Mean CPUE = 329**	**N = 17**		**Mean CPUE = 1301**
	DF	**F Value**	**p value**	**DF**	**F Value**	**p value**
Model	3	9.59	*<0.0001*	3	0.12	0.9480
Depth	1	1.89	0.1707	1	0.02	0.8831
Temperature	1	0.83	0.3635	1	0.01	0.9091
Depth*Temperature	1	0.30	0.5822	1	0.02	0.8935
October - November	**N = 131**		**Mean CPUE = 1574**	**N = 61**		**Mean CPUE = 3045**
	DF	**F Value**	**p value**	**DF**	**F Value**	**p value**
Model	3	7.00	*0.0002*	3	6.36	*0.0009*
Depth	1	2.65	0.1059	1	8.28	*0.0056*
Temperature	1	2.53	0.1141	1	9.71	*0.0029*
Depth*Temperature	1	4.02	*0.0471*	1	9.11	*0.0038*

Table 10. Analysis of Variance of CPUE (kg/hour) of rockfishes with temperature and depth of hauls. Rockfish target hauls occurred July - September only. N = number of hauls. Alpha = 0.05.

	All hauls that captured rockfishes			All hauls that targeted rockfishes		
January - November	**N = 379**		**Mean CPUE = 2074**			
	DF	**F Value**	**p value**			
Model	3	7.56	*<0.0001*			
Depth	1	0.68	0.4102			
Temperature	1	2.78	0.0963			
Depth*Temperature	1	0.14	0.7120			
January - March	**N = 31**		**Mean CPUE = 620**			
	DF	**F Value**	**p value**			
Model	3	0.16	0.9209			
Depth	1	0.06	0.8051			
Temperature	1	0.15	0.7055			
Depth*Temperature	1	0.09	0.7666			
April - June	**N = 37**		**Mean CPUE = 245**			
	DF	**F Value**	**p value**			
Model	3	3.85	*0.0182*			
Depth	1	1.16	0.2893			
Temperature	1	0.01	0.9350			
Depth*Temperature	1	1.50	0.2294			
July - September	**N = 278**		**Mean CPUE = 2716**	**N = 98**		**Mean CPUE = 7308**
	DF	**F Value**	**p value**	**DF**	**F Value**	**p value**
Model	3	11.12	*<0.0001*	3	7.19	*0.0002*
Depth	1	0.69	0.4070	1	0.11	0.7411
Temperature	1	5.16	*0.0238*	1	5.36	0.0227
Depth*Temperature	1	0.27	0.6009	1	0.06	0.8108
October - November	**N = 33**		**Mean CPUE = 81**			
	DF	**F Value**	**p value**			
Model	3	1.71	0.1860			
Depth	1	0.02	0.8852			
Temperature	1	1.37	0.2521			
Depth*Temperature	1	0.00	0.9966			

Table 11. Analysis of Variance of CPUE (kg/hour) of SW flatfishes with temperature and depth of hauls. N = number of hauls. Alpha = 0.05.

	All hauls that captured SW flatfishes			**All hauls that targeted SW flatfishes**		
January - November	**N = 636**	**Mean CPUE = 438**		**N = 87**	**Mean CPUE = 1832**	
	DF	**F Value**	**p value**	**DF**	**F Value**	**p value**
Model	3	26.08	*<0.0001*	3	4.79	*0.0040*
Depth	1	1.77	0.1840	1	0.81	0.3697
Temperature	1	0.33	0.5630	1	1.36	0.2475
Depth*Temperature	1	0.00	0.9933	1	2.07	0.1541
January - March	**N = 145**	**Mean CPUE = 427**		**N = 26**	**Mean CPUE = 853**	
	DF	**F Value**	**p value**	**DF**	**F Value**	**p value**
Model	3	6.75	*0.0003*	3	2.03	0.1394
Depth	1	14.71	*0.0002*	1	0.62	0.4400
Temperature	1	3.83	0.0525	1	1.11	0.3035
Depth*Temperature	1	13.08	*0.0004*	1	0.57	0.4566
April - June	**N = 55**	**Mean CPUE = 835**		**N = 8**	**Mean CPUE = 1556**	
	DF	**F Value**	**p value**	**DF**	**F Value**	**p value**
Model	3	2.57	0.0640	3	2.66	0.1840
Depth	1	4.08	*0.0487*	1	2.98	0.1592
Temperature	1	1.27	0.2656	1	3.56	0.1324
Depth*Temperature	1	4.55	*0.0377*	1	3.16	0.1500
July - September	**N = 298**	**Mean CPUE = 347**		**N = 33**	**Mean CPUE = 2429**	
	DF	**F Value**	**p value**	**DF**	**F Value**	**p value**
Model	3	30.03	*<0.0001*	3	1.90	0.1512
Depth	1	0.34	0.5619	1	4.71	0.0383
Temperature	1	8.99	*0.0030*	1	5.04	0.0325
Depth*Temperature	1	2.20	0.1388	1	4.57	0.0410
October - November	**N = 138**	**Mean CPUE = 490**		**N = 20**	**Mean CPUE = 2231**	
	DF	**F Value**	**p value**	**DF**	**F Value**	**p value**
Model	3	5.02	*0.0025*	3	9.81	*0.0007*
Depth	1	1.17	0.2818	1	4.24	0.0562
Temperature	1	0.63	0.4276	1	1.27	0.2762
Depth*Temperature	1	1.63	0.2045	1	3.94	0.0647

Table 12. Analysis of Variance of CPUE (kg/hour) of DW flatfishes with temperature and depth of hauls. NV = no value. N = number of hauls. Alpha = 0.05.

	All hauls that captured DW flatfishes			All hauls that targeted DW flatfishes		
January - November	**N = 436**		**Mean CPUE = 577**	**N = 83**		**Mean CPUE = 2803**
	DF	**F Value**	**p value**	**DF**	**F Value**	**p value**
Model	3	22.95	*<0.0001*	3	0.89	0.4482
Depth	1	3.11	0.0787	1	0.21	0.6508
Temperature	1	0.05	0.8305	1	0.05	0.8195
Depth*Temperature	1	0.01	0.9305	1	0.76	0.3852
January - March	**N = 54**		**Mean CPUE = 203**	**N = 4**		**Mean CPUE = 3722**
	DF	**F Value**	**p value**	**DF**	**F Value**	**p value**
Model	3	7.88	*0.0002*	3	NV	NV
Depth	1	1.27	0.2656	1	NV	NV
Temperature	1	2.42	0.1262	1	NV	NV
Depth*Temperature	1	2.15	0.1492	1	NV	NV
April - June	**N = 44**		**Mean CPUE = 1188**	**N = 16**		**Mean CPUE = 2682**
	DF	**F Value**	**p value**	**DF**	**F Value**	**p value**
Model	3	2.86	*0.0486*	3	3.23	0.0607
Depth	1	0.32	0.5736	1	0.00	0.9864
Temperature	1	0.22	0.6418	1	0.03	0.8743
Depth*Temperature	1	0.67	0.4186	1	0.00	0.9555
July - September	**N = 302**		**Mean CPUE = 610**	**N = 61**		**Mean CPUE = 2782**
	DF	**F Value**	**p value**	**DF**	**F Value**	**p value**
Model	3	4.87	*0.0025*	3	1.23	0.3077
Depth	1	0.26	0.6090	1	0.08	0.7850
Temperature	1	4.16	*0.0424*	1	0.01	0.9343
Depth*Temperature	1	0.30	0.5863	1	0.35	0.5548
October - November	**N = 36**		**Mean CPUE = 113**	**N = 2**		**Mean CPUE = 2602**
	DF	**F Value**	**p value**	**DF**	**F Value**	**p value**
Model	3	17.78	*<0.0001*	3	NV	NV
Depth	1	16.83	*0.0003*	1	NV	NV
Temperature	1	1.32	0.2599	1	NV	NV
Depth*Temperature	1	14.34	*0.0006*	1	NV	NV

Table 13. Analysis of Variance of CPUE (kg/hour) of arrowtooth flounder with temperature and depth of hauls. No hauls targeted arrowtooth flounder. N = number of hauls. Alpha = 0.05.

January - November	**N = 676**		**Mean CPUE = 737**
	DF	**F Value**	**p value**
Model	3	9.21	*<0.0001*
Depth	1	18.48	*<0.0001*
Temperature	1	8.80	*0.0031*
Depth*Temperature	1	23.19	*<0.0001*
January - March	**N = 113**		**Mean CPUE = 215**
	DF	**F Value**	**p value**
Model	3	21.60	*<0.0001*
Depth	1	4.67	*0.0329*
Temperature	1	0.00	0.9803
Depth*Temperature	1	6.18	*0.0144*
April - June	**N = 79**		**Mean CPUE = 439**
	DF	**F Value**	**p value**
Model	3	2.21	0.0941
Depth	1	4.57	*0.0358*
Temperature	1	1.04	0.3108
Depth*Temperature	1	4.93	*0.0295*
July - September	**N = 384**		**Mean CPUE = 1013**
	DF	**F Value**	**p value**
Model	3	7.05	*0.0001*
Depth	1	4.69	*0.0309*
Temperature	1	19.92	*<0.0001*
Depth*Temperature	1	1.52	0.2179
October - November	**N = 100**		**Mean CPUE = 504**
	DF	**F Value**	**p value**
Model	3	11.33	*<0.0001*
Depth	1	2.98	0.0876
Temperature	1	0.43	0.5112
Depth*Temperature	1	2.11	0.1500

Table 14. Analysis of Variance of CPUE (kg/hour) of walleye pollock with temperature and depth of hauls. No hauls targeted walleye pollock. N = number of hauls. Alpha = 0.05.

January - November	**N = 333**	**Mean CPUE = 224**	
	DF	**F Value**	**p value**
Model	3	1.39	0.2469
Depth	1	0.15	0.7021
Temperature	1	0.28	0.5997
Depth*Temperature	1	0.01	0.9301
January - March	**N = 53**	**Mean CPUE = 53**	
	DF	**F Value**	**p value**
Model	3	0.65	0.5874
Depth	1	0.56	0.4561
Temperature	1	0.03	0.8591
Depth*Temperature	1	0.59	0.4468
April - June	**N = 48**	**Mean CPUE = 238**	
	DF	**F Value**	**p value**
Model	3	0.16	0.9209
Depth	1	0.00	0.9849
Temperature	1	0.07	0.7974
Depth*Temperature	1	0.00	0.9832
July - September	**N = 179**	**Mean CPUE = 214**	
	DF	**F Value**	**p value**
Model	3	2.00	0.1156
Depth	1	0.07	0.7852
Temperature	1	0.83	0.3644
Depth*Temperature	1	0.07	0.7935
October - November	**N = 53**	**Mean CPUE = 418**	
	DF	**F Value**	**p value**
Model	3	1.98	0.1297
Depth	1	0.64	0.4274
Temperature	1	3.24	0.0781
Depth*Temperature	1	0.42	0.5190

Table 15. Number, mean depth, and mean temperature of hauls where walleye pollock were captured. No hauls targeted walleye pollock. NS = no sample.

Months	Total no. of hauls	Number of hauls	Mean (sd) depth of hauls (m)	Mean (sd) temperature of haul (^{0}C)
1995	NS	NS		
January-March	NS	NS		
April-June	15	4	203(119)	4.4(0.5)
July-September	82	43	131(58)	6.1(0.5)
October-November	36	19	77(17)	7.7(0.7)
Total	*133*	*66*		
1996				
January-March	171	53	98(74)	3.9(0.7)
April-June	72	44	126(141)	4.2(0.5)
July-September	211	88	159(67)	6.0(0.9)
October-November	NS	NS		
Total	*454*	*185*		
1997				
January-March	NS	NS		
April-June	NS	NS		
July-September	117	48	113(65)	7.5(1.7)
October-November	102	34	107(43)	7.6(1.0)
Total	*219*	*82*		
All years				
January-March	171	53	98(74)	3.9(0.7)
April-June	87	48	132(140)	4.2(0.5)
July-September	410	179	140(67)	6.4(1.3)
October-November	138	53	96(39)	7.6(0.9)
Total	*806*	*333*		

Table 16. Analysis of Variance of CPUE (kg/hour) of Pacific halibut with temperature and depth of hauls. No hauls targeted Pacific halibut. N = number of hauls. Alpha = 0.05.

January - November	**N = 627**	**Mean CPUE = 179**	
	DF	**F Value**	**p value**
Model	3	2.79	*0.0397*
Depth	1	1.54	0.2144
Temperature	1	2.90	0.0893
Depth*Temperature	1	0.58	0.4473
January - March	**N = 140**	**Mean CPUE = 41**	
	DF	**F Value**	**p value**
Model	3	5.83	*0.0009*
Depth	1	0.22	0.6434
Temperature	1	2.81	0.0958
Depth*Temperature	1	1.03	0.3118
April - June	**N = 81**	**Mean CPUE = 279**	
	DF	**F Value**	**p value**
Model	3	5.98	*0.0010*
Depth	1	4.29	*0.0418*
Temperature	1	1.69	0.1979
Depth*Temperature	1	5.29	*0.0241*
July - September	**N = 274**	**Mean CPUE = 204**	
	DF	**F Value**	**p value**
Model	3	0.25	0.8630
Depth	1	0.24	0.6223
Temperature	1	0.19	0.6633
Depth*Temperature	1	0.11	0.7351
October - November	**N = 132**	**Mean CPUE = 211**	
	DF	**F Value**	**p value**
Model	3	1.75	0.1604
Depth	1	0.96	0.3283
Temperature	1	0.18	0.6707
Depth*Temperature	1	1.14	0.2873

Table 17. Exploitable biomass, Total Allowable Catch (TAC) for all gear types and catch of Pacific cod, rockfishes (represented by Pacific Ocean Perch), arrowtooth flounder, SW flatfishes, DW flatfishes, walleye pollock, and Pacific halibut in the Gulf of Alaska.

Species	Year	Biomass (t)	TAC (t)	Catch (t)	Price/ton (US Dollars) *(2)*
Pacific cod *(1)*	1995	805,000	69,200	69,050	$418.87
	1996	760,000	65,000	68,280	$418.87
	1997	719,000	69,115	62,260	$462.96
Average		*761,333*	*67,772*	*66,530*	*$433.57*
Rockfish *(1)* (Pacific Ocean Perch)	1995	252,412	5,630	5,742	$154.35
	1996	279,431	6,960	8,378	$132.30
	1997	301,084	9,190	9,531	$154.35
Average		*277,642*	*7,260*	*7,884*	*$147.00*
Arrowtooth flounder *(1)*	1995	1,585,000	35,000	18,430	$88.18
	1996	1,640,000	35,000	22,585	$66.14
	1997	1,640,000	35,000	16,320	$88.18
Average		*1,621,667*	*35,000*	*19,112*	*$80.83*
SW flatfishes (1) (rock sole)	1995	355,590	18,630	5,430	$330.75
	1996	315,590	18,630	9,335	No Data
	1997	315,590	18,630	7,690	$330.75
Average		*328,923*	*18,630*	*7,485*	*$330.75*
DW flatfishes (1) (Dover sole)	1995	116,570	11,080	2,210	$330.75
	1996	101,430	11,080	2,200	$308.70
	1997	101,430	7,170	3,620	$308.70
Average		*106,477*	*9,777*	*2,677*	*$316.05*
Walleye pollock *(1)*	1995	1,128,000	65,360	73,250	$220.46
	1996	941,000	54,810	50,200	$198.41
	1997	1,000,000	79,980	89,800	$220.46
Average		*1,023,000*	*66,717*	*71,083*	*$213.11*
Pacific halibut *(3, 4)*	1995	83,462	10,750	9,638	$3,350.97
	1996	136,684	10,750	10,287	$3,725.75
	1997	139,708	15,422	14,952	$3,571.43
Average		*119,951*	*12,308*	*11,626*	*$3,549.38*

(1) DiCosimo and Kimball. 2001.

(2) NOAA Fisheries, Office of Science and Technology, Fisheries Statistics and Economics

(3) International Pacific Halibut Commission; Landings for central Gulf of Alaska, area 3A and 3B.

(4) Clark, W.G. and S.R. Ware. 2004.